App. F. IX-4

Previous References Geol 58-35 (1-4, 6-9 1936 (Geol) (1-20)

File No. 71-36

Serial Nos. 1-2

Letter References.

(9X)

GENERAL AND REVENUE SECRETARIAT.

Serial Nos. TWO

Part B for May 37

SUBJECT.

Report of work done by Mr K. Doraiswami Iyer during the period of his deputation to S. Africa

Ref 1397 dt 7.5.37

to Geol & Board Rep

WD 0418—GPB—22,500—20-8-36

Request him to convey the thanks of Government to the Govt of the Union of S. Africa

L-S. Afrec

[illegible] and Revenue Secretariat | Genl File No. 71 of 193 6 [App. F. III—

Serial No.

1 From the Chief Inspector of Mines & Explosives (in charge)

No 2388 dated 9/4/37

Fds a detailed report on the work done by him during the period of his deputation. L-S. Afrec.

I submit the detailed report for personal and orders. The requests made by the chief Inspector in the penultimate para of his letter is also for orders.

5- a draft may be put up

Sd

2 For perusal Sd 20.4.37

Dev Secy

3 Secretary

Sd 21/4/37

Sd 21.4.37

4 Sd 28/4/37

Sd 28/4/37

4-30

Sd 28.4.37

5

Subs with a draft.

Sd the members of committee (Paras XX to

6 Fair draft

Sd 29.4.37

Contn. Sheet.

Sd 28/4

WD 0417—GPB—80,000—8-9-36

Deputation of Mr. Divaniwanee 6
South Africa

X

651

File No. of 193 . | General and Revenue Secretariat

Serial No.

7 Send him a form letter—

Sec
30/4
Done

8 Draft Secy Lg
9 Dft in consultn with Second Mr) WA 30/4/37

SECOND MEMBER No 7869

7775/374

10 What about the Agent General Lg 1.5.37
Is it not necessary to acknowledge the help given by him also?

Sec
2/5/37

WA
3/5

Lg 3.5.37

11 Kind reference is invited (para 9 to) Govt of India's letter No Pol 1349/Genl. 5-8-36-18 dated 24/6/36 to the Secy to the Resident requesting him to communicate the thanks of H.H. Govt to the Agent-General for India, Union of South Africa, for having arranged to afford Mr. Divaniwanee the facilities asked for. In the circumstance, whether it is necessary to thank him again is for orders.

9

OFFICE OF THE SECOND MEMBER OF C MAY 1937 No 7953

It is perhaps unnecessary, in the circs.

Sec
3/5

Secy Lg 4.5.37

Second Mr) WA 5/5/37

Sec 2.5.37 Sec WA 5/5 Lg 6.5.37

TYPING & DESPATCH

Deputation of Mr. Duraiswamier to S. Africa

General and Revenue Secretariat | Genl File No. 71 1/ of 1936 | [App. F. III—2

Serial No.				
2	Pol 1397	dt 7-5-37	To Secy to Resident	
	Asks him convey thanks of the Govt to the Union Govt for the help and facilities given to Mr. K. Duraiswamy Iyer.			
	D 7496	dt 7-5-37	Copy to C I. of Police & Prisons	

B Genl 131

SEC. & REV. SECRETARIAT
18 MAY 1937
DEVELOPMENT BRANCH

NOTE—Contn. Sheet.

WD 0417—GPB—30,000—8-9-36

REGISTERED

Geol 71-36-1

GOVERNMENT OF MYSORE.

Telegraphic Address :—
"INSPECTOR"

DEPARTMENT OF MINES AND EXPLOSIVES.

10 APR. 1937
DEVELOPMENT BRANCH

Dated Oorgaum, 9th April 1937.
(S. India).

No. 2388.
Encl. one file.

5576

From

K. Duraiswamier, Esq., B.A., A.I.M.M.,
~~C.E., F.G.S., M.Sc., A.I.M.E., etc.~~

Chief Inspector of Mines and Explosives in Mysore.
(in charge).

To

M. Venkatanaranappa, Esq., B.A.,
Secretary to the Government of His Highness the
Maharaja of Mysore, Development Department,
Bangalore.

Sir,

As directed in Government Order No. D.5753-54/Geol. 58-35-3 dated 19th March 1936 I left Madras on the 8th July 1936 and arrived at Durban on the 28th July. Having interviewed the Agent General for India (Sir Raza Ali) on the 29th July, I reported my arrival in the Union to the Government Mining Engineer, Johannesburg which place I reached on the 6th August. I met the two Deputy Government Mining Engineers (Messrs. Barratt and Pretorious) as Dr. Pirow, the Government Mining Engineer was away from head quarters on tour with the Minister of Mines. The Deputy Government Mining Engineers drew up a programme of work in consultation with the Inspectors of Mines and Machinery who were introduced to me. A summary of work done has already been submitted in my interim reports. Having finished my course of study to the satisfaction of the Union Government Mining Engineer and with the approval of Government I sailed for India in the "Incomati" on the 13th January 1937 from Durban. But as the engines of the "Incomati" failed after 24 hours at sea, the ship sailed back to Durban on the 18th January 1937. I got my passage transferred to "Gujarat" a ship belonging to the same Company and leaving Durban a second time on the 20th January reached Colombo on 8th February. Leaving Colombo by rail I reached Oorgaum and reported myself for duty on the afternoon of the 11th February 1937.

During the period of my stay in South Africa, I visited the following

following Mines and Works:-

Central Rand	(1. The Crown Mines, Ltd. ...	18 visits
	(2. The City Deep, Ltd. ...	4 "
	(3. The Robinson Deep, Ltd. ...	10 "
	(4. The Village Main Reef Gold Mine	3 "
	(5. The Nourse Mines, Ltd. ...	4 "
	(6. The Langlaagte Estates, Ltd. ...	2 "
	(7. The Worcester Tributors, Ltd. ..	1 "
	(8. The New Pioneer Mine ...	1 "
	(9. The New Walhuter Mine ...	1 "
East Rand	(1. Simmer & Jack Mine ...	2 visits
	(2. East Rand Proprietory Mines ...	2 "
	(3. Modder 'B' ...	1 visit
	(4. New Modderfontein Mine ...	1 "
	(5. Doggerfontein Mine ...	1 "
	(6. East Geduld Mine ...	1 "
	(7. New Primrose Mine ...	1 "
	(8. Jumper Consolidated, Ltd. ...	1 "
West Rand	(1. Randfontein Estates, Ltd. ...	2 visits
	(2. Consolidated Main Reef Ltd. ...	1 visit
	(3. Rand Leases, Ltd. ...	1 "
	(4. Roodeport Prospecting area ...	1 "
	(5. Magalaisburg Prospecting area...	1 "
	(6. West Rand Consolidated Mines, Ltd.	1 "
Southern Rhodesia	(1. The Sun Ace & Sunday Gold Mine	
	(2. Shabani Asbestos Mine	
	(3. Selukwe Chrome Deposits.	
Northern Rhodesia	(1. NKana Copper Mine	
	(2. Roan Antelope Copper Mine	
	(3. Broken Hill (zinc, lead vanadium).	
Pretoria	(1. Premier Diamond Mine.	
Kimberly	(1. De Beers Diamond Mine	
	(2. DuToit's Pan Mine.	
Collieries	(1. Cornelia Colliery	
	(2. Springfield Colliery	
General	(Rand Carbide Ltd. Witbank	
	(Modderfontein Dynamite Factory	
	(Jupiter Rope Works	
	(Rand Refinery	
	(Klip Power Station	
	(Govt. Mechanical and Testing Laboratory	
	(Vacuum Oil Co.'s bulk storage sheds at Johannesburg and Durban.	

3 In addition to the above visits to the mines and works, considerable time was spent in the Offices of the Chamber of Mines where the several consulting engineers and experts in the various branches of mining were met and matters relating to the Mines on the Kolar Gold Field discussed. The safety first campaign and methods adopted for

the

the prevention of Accidents in Mines were studied with the help of t Accident Prevention Committee.

4 With the help of the ventilation officers of the Robinson Deep Mine - the hottest mine on the Rand - a temperature survey of the Turf Section was made and the effect of the surface cooling plant on the underground air temperatures noted. A special study of the air conditioning plants in use in the mines on the Rand was made and the manufacturers interviewed. Details of these refrigerating units are given in the accompanying report.

5 A number of visits were made to the Government Mechanical and Testing Laboratory to study the behaviour of hoisting ropes used in deep shafts.

6 The Office of the Chief Inspector of Explosives was visited several times and a number of magazines were inspected.

7 I attended several sittings of the Courts of the Inspectors of Mines and the Special Mining Magistrate's Court where breaches of the Mines and Works Regulations are tried. The Inspectors of Mines are empowered to fine up to £ 5/- and are authorised to record evidence on oath. In all cases of fatal accidents, the offenders are invariably tried by the special Mining Magistrate.

8 Several compounds where the native workers are housed and fed were visited to study the methods adopted to control their health and sanitation. Special acclimitization chambers for raw hands are provided in the big mines and schools are established at the shaft tops and compounds to instruct the raw natives in the correct and safe methods of work underground.

9 In conclusion, I beg to bring to the kind notice of Government that the utmost courtesy and kindness were shown to me by the Officers of the Union Government and the Managers of the several Mines and Works that I visited. Special thanks are due to Dr. Pirow the Government Mining Engineer and his staff for the facilities afforded

to

to me for studying several mining problems and the administration of the Mines, Works and Machinery Regulations. I therefore request that Government may be pleased to cause their appreciation of the assistance given to me to be conveyed to the Union Government.

The detailed report of my work is submitted herewith.

have the honour to be,

Sir,

Your most obedient servant,

Chief Inspector of Mines &
Explosives in Mysore.
(in-charge).

M.S

MINING IN SOUTH AFRICA.

Auriferous Reefs of the Witwatersrand.

They are regular sedimentary formations - conglomerate beds. The main reef group is represented in ascending order by the north reef, the main reef, the main reef leader, the middle reef and the south reef. The north reef is the lowest conglomerate bed of this group. It occurs from 40 to 70 ft. below the main reef, varies in width from 6" to 18" and is usually described as consisting of small white and grey pebbles up to about ½" in diameter with relatively little pyrites. The main reef is the lowest of the three economically important groups, being usually 4 - 5 ft. and sometimes 10 - 12 ft. in thickness separated by their quartzite partings The pebbles are uniform 1 - 1½" in diameter. It has been extensively mined in the Central Rand. The main reef leader occurs less than 3 ft. above this reef and frequently in direct contact with it. The thickness varies from a mere parting to 10 ft. It differs from the main reef in the greater size of its pebbles. It usually rests on the black bar - a narrow band of dark shale. The south reef occurs 60 to 120 ft above the main reef. It is frequently split up by quartzite partings. This reef varies considerably in thickness from 2 - 5 ft. The south reef is the most important reef in the Nourse Mines. Above the main reef group there are three further reefs - the Livingstone Reef, the Bird Reef and the Kimberly Reef. Banded pyritic quartzites are also mined for gold and they are sometimes from 3 - 5 ft. in thickness.

It is of interest to note that the underground development carried out during the year 1935 reached the record figure of 386 miles. The total development during the last 21 years was no less than 4,069 miles of which 96 miles were in

in respect of shaft sinking.

The production since the discovery of the Field in 1887 to the end of the year 1935 was 292,954,367 ozs. of fine gold from 873,570,055 tons of ore.

Stoping.

Stoping is all overhand or breast stoping. Some underhand stoping is done in advance in the deeper mines for the protection of the reef drives. All drilling is done by Jackhammer machines approved by the Government Mining Engineer. Axial water feed machines are used with an adequate supply of water and the size of the hole in the drill is regulated by law Each new drill is tested both on surface and underground by an Inspector of Mines to see that the Regulations are satisfied before permission for its use is granted. The steel used is generally 7/8" and two or three jumpers are used to drill a hole, which does not exceed 4 ft. The length of the working face is 250 to 400 ft. in dips of 30' and over and nearly 1,000 ft. in lesser angles with intermediate tracks. Blasting operations are confined to one shift by Law. A white miner supervises the drilling operations, marks the holes and gives the direction and charges up at the end of the shift. Delayed blasting is the usual practice and a shift boss supervises the lighting of the holes by the Tchisa boys. There is no limit to the number of holes to be lighted by a single boy who generally lights 300 holes. Explosives are issued twice or three times a week and delivered to the miner at the plat and are stored in x special boxes near the working places. Broken rock is handled by the lashing boys with shovels in steep faces while mechanical scrapers are used in flat stopes. Hand tramming is done in intermediate levels but mechanical haulage is common from the chutes to the shaft bins in the main haulage levels. Where distances are short hand tramming

is

is used in Main haulages also.

Rope haulages.- Endless rope haulages are common in the mines where the dip is flat.

Electric Locomotive haulage of the overhead trolley wire type or storage battery type are largely used. Storage battery charging stations and transformer stations have been built underground. The overhead trolley locomotive deals with trains of 8 - 10 ton side discharge hoppers. The speed of this train is limited to 9 miles per hour.

Shafts.

Almost all the old primary shafts on the Rand are rectangular vertical and timbered. They are divided into 6 hoisting compartments and a seventh capstan road where an unbalanced cage is used. Though the newer sinking shafts are also mostly rectangular and timbered a number of circular, concrete lined or lined in concrete blocks are coming into vogue. Most of the shafts on the Crown Mines are circular and lined in concrete blocks, 22 ft. diameter inside. The subverticals in this mine are all circular and lined in concrete blocks.

No.15 Shaft - Crown Mines.- This is circular, 20'-6" within concrete blocks. It is equipped with rope guides at the sides with four central ropes to prevent the cages from fouling while passing each other. Double decked cages passed to carry 50 men in each deck are in use. Truck hoisting is carried on; only waste rock is hoisted in this shaft while ore is hoisted in skips in No.5 shaft. The bottom of this shaft is the 19th level or 3,200 ft. vertically below surface.

15A. Shaft.- This shaft commences at the 18th level, this is also circular, lined in concrete blocks and 22'-6" in diameter and is in commission down to the 41st level - 6,800ft vertical

vertical depth. This shaft is equipped with two cages and two skips. Ore trucks are also hoisted in the cages in addition to the skips. Keps are provided only at the 19th level and in other places hooks hung by chains are used to keep the cage in position as ore is hoisted in both the decks These hooks have taken the place of keps because many accidents occurred as a result of the drivers carelessly bumping the cages on the keps.

15 B Shaft.- Similar to the above two shafts but is being sunk at present. The sink has just reached the 53rd horizon or 8,600 ft. vertically below surface - the deepest working point on the Rand at present. The rock temperature at this horizon was 106°F. Sinking is limited to 15 or 20 ft. according to the nature of the ground. A concrete ring is put on the levelled rock of the last blast and the blocks are then put on it. This concrete ring is reinforced by 24 plugs put into the sides of the shaft. A sinking stage is kept at a height of about 20 ft. above the sink and the ropes holding the stage act as guides for the sinking bucket. There is no ladderway but a chain ladder is always hung from the galloway stage to the sink. The stage is operated by compressed air hoists placed in front of the electric sinking hoist, only one drum of which is in use.

The sink is ventilated by means of a large pipe with canvas extension and a suction pipe is also fixed a little below the collar of the shaft. A thick canvas curtain is hung from the galloway stage to deflect any fall of rock from the open sides of the shaft. The sinkers wear heavy boots, hats and knee caps.

The shaft doors at the collar are operated by compressed air.

Incline Shafts sunk between main haulages in the Crown Mines

Mines are also lined in concrete and are solely used for men and material for intermediate levels. The ladderway is separated from the skip roads by means of strong wire netting and the drinking water pipe is used as the hand rail.

No.18 Shaft.- This is a circular vertical shaft, 3000 ft deep and is used solely as a main upcast airway. The head gear and the hoist has been removed. It is 18 ft. in diameter and lined in concrete block. The 60" Walker Fan at the top exhausts 540,000 cu. ft. or air per minute. It was upcasting 330,000 cu.ft. by natural ventilation.

Simmer and Jack: The South Deep Shaft the final depth of which will be 6,660 ft. is rectangular timbered, six compartments each measuring 10' x 5'. Eight ton skips will be installed and cages will carry 64 men. The head gear is 160 ft. and is equipped with an electric lift to facilitate going up to the top to inspect the head gear, sheave wheels etc. Where fractured ground was encountered 300 ft. of the shaft has been lined in reinforced concrete. Electric blasting is done. Hoisting is carried on by the three permanent electric winders. The sink is ventilated by means of a blower and a suction fan at the top. There is no sinking stage but at the manifold platform the shaft is covered over partially with 9" x 9" timbers and planks. The permanent timbering is kept within 100 ft. of the sink. There is no ladderway and is considered unnecessary as there are three electric winders one of which can be connected to a steam turbine in case of necessity in a very short time.

This shaft has now reached a depth of about 5000 ft. Broken rock is hoisted in self dumping skips to the shaft bin and from there conveyed by means of a belt conveyor to the trucks operated by a ropeway which carries them to the top of the

the dump where they are tipped. A phthisis beneficiary is employed to prepare the electric primers according to the plan of holes supplied to him and this saves time in making the necessary connections in the sink. He also tests the connections before sending them down.

East Rand Proprietary Mines: Central Shaft. This is one of the deep sinking shafts similar to the Simmer and Jack South Deep Shaft. It is rectangular, divided into 7 compartments - the seventh compartment is known as the service compartment used for examining the shaft etc. The final depth will be 6,000 ft. but has been suspended now at 2,000 ft as water has been struck in dolomite. The head gear is similar to Simmer and Jack Shaft and is protected by innumerable lightning conductors as this area is subject to frequent electric storms.

City Deep: No.4 Shaft.- This is a circular, concrete-lined vertical shaft. It is equipped with side guides. The cages are double decked passed to carry 55 men in each deck. Automatic decking arrangement is provided at the collar - 8 ton hoppers are hoisted in the bottom deck. These trucks run on an incline track to the tipple and then are returned to the shaft top by a loop line. The bottom of this shaft is the 17th level and from there another vertical shaft known as 4A shaft is in commission to the 31st level.

4 B.Shaft starts at the 31st level and is being sunk at present. It is an incline shaft, 35° and lined in concrete with steel arches left in at intervals. The sink is below the 37th level or 7800 ft. below datum. Large skips used for hoisting from chutes are lowered to the sink for mucking. Half the shaft is covered over above the sink and the road on one side is extended to the sink by movable rails to allow the skip to reach the sink while mucking while hoisting is in progress

progress in the top levels, the doors below the chutes are let down to prevent the spillage falling on the sinkers. Bent rails are fixed at the plat nearest the sink to divert any run away skip to the plat. These rails are always kept across the shaft while men are working in the sink.

Deep Level Winding and Safety Factor of Rope.

The Simmer and Jack South Vertical Shaft, which is still sinking is equipped with permanent electric winders capable of hoisting from a depth of 6660 ft. - the deepest one lift vertical pull. These hoists operate three pairs of skips weighing 9000 lbs. each capable of carrying a rock load of 16,000 lbs. Each winder is driven through gearing by two electric motors ~~as~~ rated at 1810 r.m.s. and 3300 peak horse power. They run at 225 r.p.m. the speed of the drums being 27.3 r.p.m. The drum makes 65.3 revolutions for the wind of 6,660 ft.

All these three winders are placed at an angle to the centre line of the shaft. The distance between this line and the centre of the drums in each case is 216 ft. The diameter of the sheaves is 14 ft. The winder motors are controlled by the Ward Leonard principle and are supplied with current from the motor generator sets. Two of these are all electric sets and the other is a Metropolitan Vickers Shebbs Perry Set consisting of a motor and two generators fitted with a fly wheel and coupled with a single reduction gearing to a high pressure condensing turbine.

The winders are of the double-drum cylindroconical type. Both the drums are loose on the shaft and each drum can be declutched and held by brakes and a spragging gear. The drums have a.maximum diameter of 35 ft. and a minimum diameter of 13 ft. They are 11 ft. 2.7/8" wide. Brake wheels are secured to the outer faces of the drums, the brake path being

18 ft. in diameter and 2 ft. wide. The main shaft is 28" in diameter and has 6" diameter bore throughout its length of 37 ft. It weighs 33 tons. A 20" diameter shaft, 4'-2" long with a central 6" bore is bolted to the other side of the main wheel. The driving gear has a ratio of 8.25 to 1 and has double helical involute teeth. Connection between the drums and shaft is made by cast steel tooth-type clutches 8'-4" in diameter with 60 teeth. The clutches are interlocked with th brakes so that a drum can not be unclutched before its brake is fully applied and the brake cannot be taken off the un-clutched drum.

The brakes are of the suspended parallel motion type. They are applied by means of dead weight of 4,160 lbs. and released by an oil brake engine. The two driving motors are of the shunt wound separately excited reversing type. They are supplied with direct current at 660 volts. Two of the three motor generator sets are all electric and consist of an induction motor with two generators and an exciter. The third set is of the Metropoliton Vickers Shebbs Perry type. It includes a motor with two generators identical with the others and in addition is fitted with a fly wheel driven by a high pressure condensing turbine through a single reduction g gearing. When the set is steam driven the induction motor is made to function as an electric brake. The turbine gears and fly wheel can be disconnected and the motor and generators operated as an all electric set taking energy from the supply mains. This system makes the winding plant an independent unit driven by a high power condensing turbine taking power from its own boilers. This system is particularly useful in South Africa on account of the risk of an outside system of electric power supply being interrupted by violent electric storms. Because of this risk and in order to ensure that it will be possible to raise men before shot firing, it is

common

common practice to have in each shaft one winding equipment independent of the electric supply system.

The ropes are made by Haggie Son & Love Ltd. of Johannesburg. They are 2" in diameter and weight 6.893 lbs per foot. They are made of flattened Strand steel and have a factor of safety of 4.8.

The plant is fully equipped with safety interlocks and automatic protective devices. Lily overwinders are fitted to each drum. The main circuit breaker can not be closed except with the slip rings of the motor generator induction motors open circuited and with the liquid controllers of the motors in the off-position. After an emergency trip, resetting can not be effected except with the control lever in the off position and the brake lever in the pull on position. After an overwind trip, an interlock prevents starting in the wrong direction. The clutches are interlocked with brakes to prevent withdrawal of clutch before the brakes are applied. The brakes are applied and the winding motors stopped automatically in the event of the failure of the current, failure of exciter voltage, over current from either the exciter or winder motors, or by the operation of travel limit switches on the depth indicators. All the motor generator sets are fitted with overspeed trip devices. Horizontal metallic rods are provided 6" below the drums and when the rope becomes slack and touches these rods an electric hooter in the driver's room is sounded to warn him of the slack rope.

Exemption from Regulation 37 (ii), Safety Factor of Ropes:-

If Y_1 denotes the factor of safety at lower end of rope and Y_2 factor of safety at the upper end of the rope, it is considered safe practice in a vertical shaft of great depth to allow Y_2 to reduce to 5, provided Y_1 does not reduce to below 8. According to sound practice, the percentage reduction from

from the initial safety factor to the one at which the rope must be discarded should not exceed 25.

On discard, factor of safety	Y_2 for persons	= 5.6	}	
do. do.	Y_2^1 for persons	= 10.4	}	E.
	Y_1^1 rock	= 8.8	}	R.
Initial factor of safety - new rope	-persons	= 6.8	}	P.
do.	rock	= 6.2	}	M.
Strength reduction (safety catches, attached).		= 18.3%	}	

It is undesirable to permit the discard factor of safety for rock to fall below 4.7.

By apparent factor of safety is meant the ratio between the breaking strength of rope and the maximum static pull in the rope due to its own weight and depending load. The actual factor of safety in addition to the foregoing takes into account the effects of bending, acceleration and kinetic shocks. The capacity of a rope to resist kinetic shocks depends upon and is roughly proportional to the weight of the rope and since weight and length are proportional, it is evident that a long rope is better able to resist such shock than is a short rope.

In deep shafts it is well to eliminate the shock of starting and to decrease the stresses of acceleration.

The ratio between the breaking strength of the rope and the load depending from it, is called the capacity factor, the weight of the rope itself not being taken into account. It is recommended to make this factor equal to 12 for all depths down to about 5000 ft. When the load has reached the collar of the shaft, it is 12. After a certain critical depth the effect of kinetic shock is either constant or possibly diminished due to damping of the vibrations, but within the critical depth, the ~~wave of~~ stress doubles and redoubles on itself and enormous stresses may thereby be occasioned. At the critical depth the rope will weigh .35 of the load carried at its end.

Winding Plant - Rope Factor of Safety -E.R.P.M. The winders

winders would be of the Ward Leonard Control type with Ilgner fly wheel and drums of the bi-cylindroconical type - 15' small barrel diameter and 30' large barrel diameter. The accelaration rates are 2 ft. per second on small drum and 1 ft. per second on cone and 4 ft. per second on large diameter. Oil governed brakes will probably be installed to ensure that the rate of braking will not exceed a predetermined value of the order of 10 ft. per second referred to the large diameter of the drum.

The rope on which these calculations are based is 110/120 ton steel, flattened strand construction 1.6875 inch in diameter, weight 5.18 lbs. per foot and with an actual breaking strength of 261,400 lbs.

Both the skip conditions comply with regulation 34/8 inas-much as that the weight of persons and cage (7500 plus 7680 = 15,180 lbs.) is less than 85% of the weight of rock plus skip which is 20,970 lbs. and 17,900 lbs. respectively for steel and duralumin skips.

The minimum factors of safety have been calculated as follows:-

(a) Load on rope at sheave with load at bottom

Rock		Men & Material	
Rock ..	12,000 lbs	Men or Material ..	7,500 lbs.
Skip ..	5,900 "	Cage	7,680 "
5300' rope	29,835 "	5300' rope ..	29,835 "
	47,735 "		45,015 "

Actual initial breaking strength of rope = 284,000 lbs.
Initial Factor of Safety - rock = 5.95
Initial Factor of Safety - men and material= 5.01

(b) Load on rope at point of attachment

Rock ..	12,000 lbs.	Men or Material	7,500 lbs.
Skip ..	5,900 "	Cage ..	7,680 "
	17,900 "		15,180 "

Initial

Initial Factor of Safety	- Rock	=	15.86
do.	- Men or Material	=	18.7
Discard Factor of Safety	- Rock	=	12.57
do.	- Men/ Material	=	14.8
Ratio =	Man load / Other load	15,180 / 17,900 =	0.848

Reason for making an application for lower discard factor of safety than is permitted in Regulation 37 (ii) is shown hereunder:-

(1) Regulation 37 (ii) provides for such exemption being considered in terms of depth and speed.

(2) The depth of shaft - 5,300' from bottom landing to sheave is such as to result in a high reserve of strength in the rope, which it is generally agreed is suitable provision for kinetic stresses.

(3) The winder being Ward Leonard Electrical control there can be no excessive accelerations and decelrations with consequent increase of kinetic stresses. In this particular case, the normal designed accelerations are of very moderate account being 2 ft. per second on small cylinder of drum, only 1 ft. per second on cone, and 4 ft. per second on large cylinder of drum.

(4) With gravity brakes oil controlled pressure by governor to definitely fix the maximum rate of brake retardation irrespective of the load being handled, the kinetic stresses from breaking are minimised.

(5) Tests have shown that loading stresses from load poured into skips in deep and moderately deep shafts are negligible and that little increase of kinetic stresses occur from this cause.

Supports

Supports.

Timber is freely used as supports in excavations. Square timber for special purposes is imported from Australia but generally blue gum and wattle poles are in use. Used as single props, the size varies from a mere sprag of a few inches diameter to large stulls. In areas where the angle of inclination is over20° the poles used for pigstyes are joggled or wired to keep them secure.

In the far east Rand, timber cribs are replaced by concrete discs - pancakes - carrying a timber capping. These discs are made on surface and sent underground. This form of support is suitable to this area because the footwall is shale - a fine grained quartzite slate which takes and appreciable punch from the pressure of the hanging wall.

Chock packs or mat packs are extensively used in the Central Rand. These consists of round or square timber of 3 pieces laced by wire and they are 2' x 2'. Nine points packs consist of 6 pieces jointed by wires at nine points and are 2'-6" and 2'-6" and these are used for pigstyes and the space between them is filled with rock.

All the necessary timber is supplied to the Mines by the exchange yard - a department of the Rand Mines group situated in Johannesburg.

Rail arches the legs of which imbedded in concrete in iron pipes are used for haulage supports and in dangerous places completely lined in concrete. Square sets have been discarded. Steel girders as caps have also proved incapable of resisting pressure.

Sloan wire packs are also in common use the wire net being used to keep the waste pack in position

Reef packing or shrinkage stoping is the common practice

in

in the Central Rand. The reef is subsequently reclaimed and the area supported with waste packs. Waste packing is also used in the far East Rand Mine's also and these packs are put in as soon as the ore is removed by the scrapers. As a rule, the waste rock is picked out and packed into the stopes systematically.

Sand filling which was a common practice some years ago has been given up and waste packing has taken its place. Pillars are also left systematically as supports and are subsequently reclaimed.

Stoping Method in Randfontein.- The normal strike of the reef is north and south and the dip is between 60' and 90'. Two ore bodies are being mined - the Randfontein Leader and the west reef which lies about 180 ft. in the footwall. The exploitation of the reefs is by means of rock tunnels, 9'x 9' driven in the footwall and parallel to the west reef. Crosscuts from this tunnel are put out at intervals of 500 ft. to intersect both the reefs. Then winzes or raises are put out on the dips of the reef to connect the levels. Then stoping is commenced. The stope face is kept about 50° with the horizontal. Loaded stulls supported on chock packs built up of 2' x 4" timber form the main support in the excavation. Broken ore is removed from boxes where the ore collects by gravity.

Resuing in City Deep:- This method involves the stoping of the waste above the reef for the required width for a distance of 8 or 10 feet, at a time and the resulting waste rock is used for packing the excavated area before blasting the reef with "pop" holes later on. This is known as footwalling the reef. If the reef is very narrow, the waste is stoped for at least 36" to get a sufficiently wide excavation to work in. The angle of the stope face is carried perfectly straight with an angle of about 45°. In starting off from the raise, the stope is opened up full width for a length of 50 ft. on each

side

side of the raise along the drive. Pigstyes are built ahead of the resque face along the N. side of the track and ~~spread~~ spaced 4 ft. apart to provide outlets for the broken reef during the footwalling period.

Before resquing is started, a row of 7" sticks, 7 ft. apart is put in along the face about 2 ft. away from the face. A barricade of lagging is built up on the inside of these sticks up to the height of the waste wall. As soon as the installation of the barricade is completed, waste stoping is started. During the advance of waste stoping, the hanging is supported by stulls. The broken waste is lashed in behind the barricade and when it reaches the barricade waste stoping is stopped and footwalling of the reef is commenced. Footwalling is done by popholing and barring and it is carried to 1 or 2 ft. of the waste face and then the waste stoping is resumed.

The advantages of this system are

(1) The excavated area is filled nearly 100% with waste rock to within 20 ft. of the face before the sagging of the hanging takes place; this condition is analogous to the old sand filling method.
(2) All air circulating from level to level passes along the stope face.
(3) There will be no old workings to reclaim.

The waste stoping period is usually 10 to 15 days and the footwalling period is six to eight days.

Remnants.

Remnants are small pillars of ore formed as a result of stoping operations and special care is usually taken in extracting them. The size of a remnant varies from mine to mine and special instructions are issued to mine them. Tunnelling into a remnant is dangerous. Remnants are also produced by stoping up to a dyke fault or boundary line.

The following instructions have been issued for working remnants

remnants in Crown Mines, Ltd.:-

Definition: A remnant is a block of ground which has an average width of 150 ft. or less on the strike or which measures 150 ft. or less on the dip

Reporting: The Remnant Officer notifies the section manager when a block has reached the remnant stage and provides him with a plan showing the positions of the workings within a radius of 300 ft.

Log Book: A log book is kept at each shaft in which all occurrences are recorded for each remnant. The following precautions are taken during the working of the remnant.

(1) The maximum number of persons to be employed is fixed by the Manager.
(2) Samplers and Surveyors are not allowed in the remnants except with the permission of the Manager. No sampling is required for remnants.
(3) The top portion of the remnant faces are where practicable carried on the full dip-line to a point 40 ft. below the level.
(4) Faces are supported strongly by substantial sticks, packmats or sandows in addition to reef packing.
(5) As soon as two faces meet, a chute line is packed off from the bottom drive and follows the toe of the remnant up.
(6) Extra escape ways are packed up to the faces where necessary
(7) No shrinkage is removed from the neighbourhood of the remnant until it is worked out.

General Precautions against Pressure Bursts.

When a pressure burst has occurred, now work is permitted in the place until after 24 hours, except when rescue operations are necessary.

Where practicable, in addition to the ordinary excavation of the south sides of the drives; top slices are taken off blocks before they reach the remnant stage in order to further protect the drives.

The number of remnants worked at one time within a given area is limited.

Reef is stoped out to a distance of 12 ft. on each side of the drives before the blocks being worked reach the remnant stage.

Drives

Drives passing through shaft pillars are stoped out 30 ft. N. & S. of the drives for a distance of 100 ft. from the edge of the pillar.

Narrow reef tunnels are avoided in areas subject to heavy pressure.

Simultaneous working of superimposed faces is prohibited.

Reef over incline shafts is worked out early and rapidly on the full dip line.

Efforts are made to reduce the number of remnants worked by not working more faces than are required.

Narrow tunnels in dykes or faults which are liable to pressure are protected by timbering or steel arch sets with cushioning between the support and the rock.

Special underground rescue stations are provided containing all equipment likely to be required in the case of a rockburst, such as picks, shovels, pinch bars, short jacks, trench tools etc.

Hot coffee, sandwiches and a good supply of drinking water and lime juice and salt mixture are made available to the rescue parties.

Pressure Bursts & Hanging Control.

There are two methods of defining remnants based on the size of the block and the liability of the blocks to burst due to local conditions such as faults or dykes. In most mines subject to rockbursts remnant officers are appointed and a complete record of all occurrences in the area is maintained.

The following precautions are taken to minimise the effects of rockbursts:-

(a) Stripping the sides of the drives, crosscuts etc.

(b) Removal of the ground over footwall excavations such as shafts haulages etc.

(c) Lay out to minimise the number of remnants.

(d) Predetermination of the method of support where the final remnant will be formed.

(e) Limitation of the number of persons employed on remnant work.

(f) Regulating the speed at which the remnant is to be worked.

(g) Provision of adequate escape ways.

The Robinson Deep Mine has adopted the following methods to minimise the effects of bursts:-

(1) Vertical Shafts. Where the shaft passes the reef an area of 1000 ft. x 1000 ft. is left intact.

(2) Inclined Shafts. The overlying reef is stoped out. The hanging and sides are kept clear of the shaft timbers.

(3) Reef drives are protected by north and south siding and by rapidly stoping the bottom points of remnants.

(4) Footwall drives are supported by timber.

(5) Engine rooms, rope races etc. by stripping the hanging and sides clear of the supporting structures.

(6) Stopes systematically supported with packs kept close up to the face.

Sag-meters - Crown Mines.

These instruments have in their construction an indicating arm showing the relative movement of the foot or the hangingwall These movements are much magnified and recorded on a chart fixed to a drum actuated by a clock. Thus the hanging wall subsidence is continuously recorded in the required area. The curves traced on this chart were found to be regular in the working faces of remnants but they appear to be parabolic or irregular after the blast had taken place. Blasting caused a definite major movement. If the chart indicates a rapidity of subsidence, it is considered to be a definite indication of a major movement in the vicinity of a remnant. If this phenomena takes place, persons are not allowed to remain in the vicinity of the

remnant

remnant. Thus the occurrence of a burst can be predicted. But more work has yet to be done to determine the speed of movement to predict the exact time and place of a pressure burst which is dependent on constantly varying underground conditions.

Observations of the sag meters showed that the sag was intermittent. Face advance is almost the only cause of pressure bursts. Cracks and cleavages are the direct manifestation of the pressure effect. It is essential to have a full and heavy blast on every blasting shift for, when the period of instability prior to a failure is reached, it is essential to bring about the failure as speedily as possible after all the persons have left the working place. A record of pressure bursts have shown that the majority of them have taken place after the blast.

When the strata forming the roof of any extensive void collapses, an earth tremor is the result. Earth tremors and pressure bursts are independent phenomina as to cause although each may be able to set off the other. For example, pressure burst might occur at a distance away from the centre of the disturbance of an earth tremor which caused it.

General Safety Measures to Combat Rockbursts.

As shearing on the face is the cause of throwing the face rock out into the open workings, it is recommended that the face be kept with as few irregularities as possible without benches, corners etc. Stab holes are not recommended as they create an internal bench throwing the line of shear into the solid thereby increasing the danger possibilities from the face itself.

Rapid and continuous working of the face is not considered as important as the complete working of the face i.e. when blasting

blasting, every blast should be a full blast. If the number of persons employed on a remnant be limited, two or three days drilling be blasted at one time and this is considered to give the greatest measure of safety. If the holes drilled one shift are lost and if left over for the succeeding day, then some measure such as doubling up the machines to get a full blast is recommended.

If the undermined "live ground" is rigidly supported it may be maintained in place for a longer period, grow in weight and probably result in intensifying the burst when it occurs. Weakening of the support might tend to increase the frequency and decrease the intensity.

Some form of indestructible support as near the face as possible is recommended to prevent the overburden from dropping completely into the open working space on the face.

Some regional support, such as resume waste fill permitting a minimum regional subsidence is recommended.

Changing the method of support might change the interval of the burst.

Slips and faults in a remnant cause a burst especially if the face is carried in a more or less parallel direction. It is recommended that faces be carried across such slips or faults in as far as possible. Further more a burst should be anticipated on a parallel slip or fault for which reason these should be located and plotted and the face advance with respect to them recorded.

One stope under observation could be divided into three sections, the top and bottom being subject to pressure bursts and the centre being subject to such burst. The effect of bursts in the centre section are usually transmitted to a haulage beneath and rarely felt on the stope face itself.

It is considered that every working place subject to any

kind

kind of rockburst phenomena should be studied individually.

DEEP LEVEL MINING PROBLEMS.

(i) Ventilation.

In mining at great depths, the question of ventilation is of the greatest importance. An adequate quantity of air of as high a cooling power as possible should be supplied to all the working places to avoid discomfort to the workmen. On the Rand Mines a large quantity of air is kept in circulation throughout the mine workings by means of powerful fans erected at suitable places to obtain the maximum amount of benefits. In addition to the large fans, auxiliary fans, boosters, and venturi blowers are used to force air to the development ends. Compressed air jets being inefficient are not being used at present but compressed air induction blowers delivering through large diameter pipes, preferably of galvanised iron carried to within a few feet of the face are common. The air must be delivered with sufficient velocity to reach the actual face despite the exhaust air issuing from the machines. Exhaust method of ventilation as a means of removing dust produced in blasting is also used in many mines.

In some of the ultra deep mines the cooling power of the air is greatly reduced owing to saturation and high wet bulb temperatures resulting in discomfort to the workmen and consequent loss of efficiency. Fatal heat stroke cases have also occurred in these mines. This problem of producing high cooling power in the air is being solved by mechanical refrigerating plants of different types which are being tried in four deep mines - The Robinson Deep, The East Rand Proprietory Mine, The Doggerfontein Mine and The Crown Mines, Ltd. Except the Robinson Deep plant which has been in commission for about a year, the others are new and have not had sufficient running

period

period to enable one to judge their cooling powers.

Air Conditioning Plant - Robinson Deep.

The ore extraction operations are in progress more than 8000ft. below the surface vertically.

The plant consists of three carrier centrifugal refrigerating machines each of which has a rating of 750 H.P. and employs a non-combustible and non-toxic refrigerant ($CF Cl_3$) trichloroflouro methane - known as Carrene- a carrier spray type dehumidifier - 49' x 24' x 19' with a capacity of 400,000 cu.ft. of air per minute, and using 8,400 gallons of spray water per minute. A condensing water spray pond 96' x 252' equipped with 306 nozzles three condensing water pumps, each handling 2,500 gallons per minute, two high efficiency fans with a capacity of 200,000 cu.ft. of air p.m. In operation 7,500 gallons of water per minute will flow through the piping to the water pumps. These pumps will circulate the cooled water through the condensers of the three refrigerating machines. The liquid carrene is in the base of the evaporator or cooler, through the tubes of which is the water or brine desired to cool. A minus pressure in the cooler is maintained by the centrifugal compressor. The centrifugal liquid pump, enclosed within the base of the cooler lifts the liquid refrigerent to the space above the tubes, from which a distributor makes it fall over the tubes. At the low pressure i.e. high vacuum, the liquid boils or evaporates rapidly quickly absolving its latent heat of evaporation from the brine or water flowing through the holes, thus performing the objective cooling effect.

Then the resulting vapour passes through the stationery eliminator plates which remove any entrained liquid and enters the centrifugal compressor wherein the pressure is increased (or the minus pressure is reduced). At its relatively higher pressure, the vapour enters the condenser and circulates about the tubes through which the condenser cooling water flows. In the conden-

ser

ser, the compressed vapour, which will now readily condense at above 90° gives up the cooling water its latent heat of liquefaction. Thus the vapour becomes liquid again falls into the space beneath the condenser tubes and from there it flows through an ordinary float trap back into the cooler thus completing the cycle.

The cooled water then passes to the sprays of the dehumidifier. Air is constantly drawn through the dehumidifier by the two 200,000 cubic foot per minute fans, the air in passing through the series of finely atomised sprays being cleaned, cooled and dehumidified. The two fans discharge the air from the dehumidifier to the main vertical shaft through an underground tunnel thus enters the shaft at a point 100 ft. below the shaft collar. Thence the air is drawn downward into the mine by a fan situated at the 33rd level at a point between the main incline and the sub-incline shafts which is 6204 ft. below the collar of the vertical shaft and then split off into the working areas. After passing through the working places, the air rises through worked out areas and eventually reaches surface through upcast airways.

Refrigerating capacity of the plant exceeds that of 2000 tons of ice equivalent to a heat extraction of 24,000,000 B.T.U. per hour from an air volume of 400,000 cu.ft. per minute entering the mine.

About 3000 H.P. is used in pumps, motors etc.

The cost of the installation was £ 125,000 and it costs £ 1,000 a month to run it.

It is not run continuously; closed down at the end of the afternoon shift. It is not run at all during winter if the air temperature approaches the freezing point. The Managers consider, the conditions at the bottom of the mine have

have greatly improved. The plant has not run for a sufficiently long period - commenced operating in August 1935 - to appreciate its beneficial effects.

The following figures give an idea as to the benefits derived from the plant:-

	Average Temperatures 10/34 to 8/35		Average Temperatures 10/35 to 8/36		Percentage increase in Wet Kata
	Wet.	Dry.	Wet.	Dry.	
Vertical Bottom ...	61.9	63.5	56.4	57.3	15
33 Fan Intake ...	72.4	75.5	66.8	69.7	21
33 Fan Discharge ...	75.3	82.9	69.6	77.4	24
39 Station ...	78.7	84.5	74.4	79.9	22
40 E. Station ...	79.4	84.6	74.6	80.3	25
40 W. Station ...	79.6	84.3	74.7	79.6	25
40 Main Crosscut ...	80.9	85.1	76.3	81.0	26
40 E. 4. Crosscut...	82.2	85.8	78.8	82.5	20
40 E. 5. Crosscut...	82.8	86.3	80.2	83.8	16
40 E. 7. Crosscut...	83.2	86.7	80.6	84.3	17
40 E. 8. Crosscut...	85.3	88.4	83.0	86.6	17
40 E. 8. Bottom ...	87.2	89.6	86.3	88.8	8
40 E. 8. Top ...	89.9	91.3	89.1	90.6	9
40 E. 7. Top ...	89.5	91.3	88.0	90.5	16
40 E. 5. Top ...	87.8	89.8	87.7	89.3	1
40 E. 4. E.Top ...	89.8	91.1	88.8	91.9	11
40 E. 4. W.Top ...	87.7	90.3	86.3	89.0	12
40 E. 2. E.Top ...	87.2	90.1	85.3	86.7	17
39 E. 3. E.Bottom...	87.7	91.0	85.8	88.3	17
41 E. 3. Top(Raise)	85.7	90.4	83.5	87.5	17
Airways (Mean) ...	78.6	82.6	74.0	78.5	23
Workings (Mean) ...	87.9	90.2	86.5	89.0	13

The cooling produced is entirely due to the cooling plant. Owing to the exigencies of mining, it has been impossible to maintain standard conditions. As a matter of fact it can safely be assumed that the cooling effect would have been greater if conditions had remained standard. A case in point is 2.E.40.E. stope, where a total cooling of 2 degrees in the wet bulb and 3.5 degrees in the dry bulb temperatures have been procured as compared with the mean drop in tmperatures of all stopes included in the survey of 1.5 degrees in wet bulb and 1 degree in dry bulb.

In all probability the results obtained in 2.E.40.E. would have been better but for the fact that during the first

period

period there had been no face advance and consequently rock cooling had taken place. During the second period fresh rock surfaces were continually being exposed.

Apart from the change mentioned in the preceding paragraph, conditions with regard to 2.E.40.E. have remained constant in that the holing below it, which provides the intake air, had been established since 1932.

A further reason for taking 2.E.40.E. as being truly representative of what can be achieved by the plant is that the holing providing the ventilation air is situated in such a position relative to the face that the air naturally courses along the face. It must be borne in mind, however, that the quantity of air passing through 2.E.40.E. is nearly 18,000 cubic feet per minute, which is made up of 12,000 cubic feet per minute coming along 41 Level Reef Drive from the central winze which is the upcast from 44 to 46 Levels, West Sub-Incline Shaft; and 5,000 cubic feet per minute upcasting from 42 and 43 Levels. The large quantity is, therefore, offset against the increased temperatures. In reviewing the results procured in other stopes some illuminating points crop up.

Firstly, 4.E.40.W. shows a cooling of 1.4 degrees on both bulbs, whereas 4.E.40.E. shows a drop of 1 degree on the Wet and a rise of 1 degree on the Dry. This is explained by the position of the crosscut which causes most of the cool air ex 40 Footwall Drive to go up the West face, whereas the air traversing the east face comes all the way up from 42 Level, via 5.E.42 Raise, 5.E.41 Raise and 4 A.E.40.E. Stope.

Secondly, In 5.E.40 there has been practically no cooling due to only 6,500 cubic feet of air per minute being available ex 40 Footwall Drive for both faces. In addition the faces are moving away from the source of ventilation making it

it increasingly difficult to course the air along the faces, the shapes of which, due to dislocations, are not conducive to good ventilation.

Thirdly, in 7.E.40 and 8.E.40 a drop of approximately 1 degree in both wet and dry temperatures has been obtained despite the facts that these stopes are near the boundary, are partly ventilated by air from the lower levels and have considerable faulting, which makes good air coursing extremely difficult.

The effect of the cooling plant along the split from 40 Station up to 8.E. Crosscut, which comprises a total distance of 3,700 feet passing an initial quantity of 48,000 cubic feet per minute during the first period and 38,000 cubic feet per minute during the second period, is shown by a drop of 4.9 deg wet and 4.7 degrees dry at the stations, a drop of 4.6 degrees wet and 4.4 degrees dry at the South end of the main crosscut, a drop of 3.4 degrees wet and 3.3 degrees dry at 4.E.40 Cross-cut and a drop of 2.3 degrees wet and 1.8 degrees dry at 8.E. 40 Cross-cut.

East Rand Proprietary Mines Ltd: Air Cooling Plant - Underground.

This plant which is known as the "York" air conditioning plant works on the same principle as the Robinson Deep plant but is situated at a depth of 6400 ft. below surface. It consists of two units each with a duty of 3,000,000 B.T.U. per hour equal to a daily duty of 600 ice tons or the capacity to cool 150,000, cu.ft. of air per minute $9\frac{1}{4}^{o}$F wet bulb. Approximately 70,000 gallons of condenser water is used per hour. The temperature of the intake water is 84^{o}F. and the discharge water is 95^{o} F. The temperature of the intake spray water is 66^{o}F. and the discharge is 75^{o}F. The limitation here lies in dissipating the heat from the condense water

water which includes all the heat taken from the air passing the cooler as well as that of the plant. This warmed water is pumped to surface.

The refrigerent used is Freon - Dichloro-Di Fraro-Methane. Relatively warm water is circulated through the water cooler tubes which are in contact with liquid freon at the bottom. The radiated warmth of the tubes causes the freon to boil, thus releasing freon gas to the upper portion of the water cooler. The compressors are now started up and they draw freon gas from the water cooler thereby reducing the pressure within it causing the freon to boil more readily and replace the emptied gas space by more gas at a balancing rate with the demands of the compressor intakes. When the gas is compressed its volume is reduced and the temperature is increased in direct proportion, thus hot freon gas at 125 lbs. per sq. in. is introduced into the condenser at a temperature of 104° F. The cooling water flowing through the condenser at an initial temperature of 84° F. reduces the temperature of the freon gas to the temperature of the cooling water and this drop in temperature causes the freon gas to condense and become once more fluid and is ready for use again in the cycle of operations.

While expanding from the liquid to the gaseous form the necessary heat for expansion is taken from the circulating water in the water cooler tubes reducing its temperature from 75.7°F. to 66.25° F. The water thus cooled is forced to the sprays in the air washers where it is atomised over the flow of air from the main fan which is delivering 150,000 cu. ft. per minute at a velocity of 900 ft. per minute.

The air from the fan has a wet bulb temperature of 82.5 °F and after passing through the air washer which absorbs some of its heat in the process of conduction thereby reducing its temperature to 73.25° F. wet bulb. Mine air is thus reduced

from

from 82.5° wet bulb to 73.25° F. wet bulb. The quantity of air treated calls for 500 tons of refrigeration per hour by the elimination of six million B.T.U. of the heat normally carried by it

The cost of the bare cooling plant is £ 25,000. This plant has only been recently started and no definite results have yet been obtained. In fact it was started only a week before my visit.

The following facts are of interest:-

Rock temperature at 6000 ft.	..	93° F.		
Do. 7300 ft.	..	100° F.		
Air entering plant	84°F.	dry	and	82° F. wet
Air leaving plant	73°F.	"	"	73° F. "
Upcast air	~~89°~~ 89°F.	"	"	87° F. "

Air Cooling Plant - Crown Mines - 14 Shaft.

The plant is manufactured by the Brown Boveri Ltd., Baden Switzerland and is known as the Brown Boveri Frigi bloc.

A fully cased in regrigerating turbo-compressor.- The capacity of the plant is 3,300,000 B.T.U. per hour consumption of current 197 kilowatt per hour. The cost of the plant delivered at the mine was £ 9,000 and the labour and erection cost met by the mine. Cooling water used about 40,000 gallons per hour and it rises in temperature about 8° F. i.e. from 82° to 90° F. The charge consists of 18,000 lbs. of ethyl chloride and the loss of refrigerent in working is negligible. The maximum pressure in the plant is 20 lbs. per sq. in.

This refrigerent is claimed to be neither explosive nor inflammable unless under very high temperatures. This unit is used for cooling 50,000 cu.ft. of air per minute.

The following temperatures were taken on 10-11-36:-

Surface

Surface ..	62.5° F. dry and	59.5°F. wet
29 level ..	84° "	72° "
(4000 ft. vertical) 41 level - location of the plant 6000 ft. air inlet	89°	79°
Outlet	74.5°	74.5°

As the plant has been put in commission only a few days ago, no further date is available.

It costs about £ 300 a month to own it.

Daggafontein Mines, Ltd: Compressed and Devaporised Air Refrigeration.

The cooling plants described in the foregoing pages involv the use of a large quantity of cooling water and the resulting hot water must be disposed off without allowing it to give the heat back to the air. Large quantities of cold dry air is produced in this mine by the use of compressed air for driving machinery - pumps underground. The air compressor is on surface and the expension machine producing sub zero temperature is underground nearest to the point of application. When work is performed by air during expension - driving a pump or hoisting rock, there is a pressure drop and a corresponding temperature drop which may lead a final exhaust temperature of minus 70° F. Ice troubles would be experienced if the air were not devoporised or dehumidified. This cold exhaust air can be mixed with the mine ventilation currents to improve the cooling power. The most convenient place to remove the water from the air is an surface before the compressed air enters the mine. A plant capable of compressing 10,000 cu.ft. per minute of free air and delivering it in a dry condition is now in use in the East Daggafontein Mine. The air is compressed to a high pressure than that at which it is required and then to expand it in an air engine to the working pressure. This expansion is adjusted to cool the air to 32° F., water vapour is thereby condensed and

is

is separated and trapped. The plant consists of a cross compound two stage compressor to which two extra cylinders and coolers have been added. The overcompression to 130 lbs. is performed in a third air cylinder. The air then passes through an after cooler and into a heat exchanger where it is further cooled. It passes afterwards into a cylinder, also coupled to the compressor where it expands and in expanding assists in driving the compressor. The exhaust from this cylinder at 32°F. and slightly more than the working pressure of 80 lbs. passes through a water separator and scrubber where the condensed water is extracted. The cold dry air is then passed through the heat exchanger and is delivered to the mine at a normal temperature of 70 - 80°F. and at the working pressure of 80 lbs. There is little to be gained by supplying the compressed air to the mine at a low temperature as it would immediately absorb heat on its way down the shaft.

Dehumidified compressed air may also be produced by turbo-compressors which have a great advantage in size over reciprocating compressor. A turbo de-humidifier of the German make has been installed at the Daggafontein Mine. An electrically driven devaporising turbo-compressor of 14,000 C.F.M. capacity and two 400 H.P. toothed gear type air motors driving centrifugal pumps are in use. These pumps are installed at the bottom of No.3 shaft - 4000 ft. below surface and are worked by two Demag air motors and the exhaust air which is at 40° F. is led into the main haulage through 700 ft. of 18" pipe covered with 2½" cork and two 15" branches are similarly covered for 500 ft. At the end of the pipes, the temperature was - 24° F. proving that ultra cold air can be conveyed considerable distances without picking up much heat. At one stope where the temperature used to be 80° F. it was reduced to 68° F. with the air motors running. A distinct improvement was noticed in the atmospheric conditions when the rock drills were run on dehumidified air. Air motors using devoporised compressed air may be placed at points near to the working places to produce local cooling.

At

At the points where the galvanised pipes are not insulated, ice about 12" thick is formed for a long distance. This plant is worked only till 10 A.M. daily as the cooling effect produced by running the plant for 3 hours is sufficient to last for the whole shift.

Accident Prevention and Safety First.

The Chamber of Mines have organised an accident prevention committee consisting of mine managers, medical officers and Government Inspectors with the object of concerting measures for the prevention of accidents. Meetings are held regularly and accident statistics are considered and several safety devices are discussed and put into practice. Occasionally special sub committees are appointed to consider measures for the prevention of accidents resulting from explosives, trucks and tramways and special precautions are drawn up and given wide publicity by means of safety posters. A prize scheme is also in force and at the end of each year the Government Mining Engineer presents the statue of safety to the mine which has the lowest number of recorded accidents. The poster campaign is vigorously carried out. It has been found by experience that negative representations were capable of leaving wrong impressions on the mind of the native and so the new posters will show only the correct ways of doing things.

All the possible sources of danger are shown to the natives at special model schools on the shaft top. At the compounds, boss boys give lectures and show the explosives and other articles which are likely to injure them if they are not careful. In addition, the loud speakers are freely used; placed at convenient places in the compounds. Occasionally the mine managers or some responsible underground official gives a talk on accidents. The movies are shown weekly in the compounds and in the interval special accident prevention films are interposed.

The

The necessary appliances for the protection of the workmen are supplied in the compounds and their use is enforced. Every native is given the necessary clothing, boots, leather leggings, arm bands etc. For persons engaged in breaking boulders, goggles made of wire gauze are given. Safety devices are attached to the implements handled by the natives to protect them. Pinch bars are provided with rubber rings or metallic hoods attached in the middle to defleat the falling rock away from the hands of the operator. The trucks are provided with bars for pushing instead of using the edge of a full truck. The tramming boys carry shistles and blow them while taking a bend to warn the approaching persons.

The gangers and miners who are in charge of the natives are instructed to carry out the regulations strictly so that nobody is exposed to danger.

The native boss boys are trained in First Aid work and the certified ones wear a red-cross and render first aid in all cases of accidents. Natives coming off work are examined for scratches and wounds and are treated at the shaft top. Again they are inspected in the compounds and dressed. Injuries requiring medical aid are sent to the hospitals.

Dust Control and Prevention of its Circulation in Air.

As fine dust has been proved to be the cause of phthisis special regulations have been drawn up and rigorously enforced in all the scheduled mines . Wet drilling is the common practic and no new drill is permitted to be used in the mines unless it has been approved by the Government Mining Engineer. Before a rock drill is approved, it is tested on surface by an Inspecto of Mines to find out the quantity of air that goes through the axial hole along with the water. A rubber tube is connected to the jumper and the air that escapes is collected in a graduated bottle. This is known as the bottle test. If the

leakage

leakage is more than 10,000 c.c. per minute the drill is condemned as it is known that this air produces harmful dust while the drill is working. Three underground tests are then made while the holes are being drilled and dust samples taken by konimeters. If the count exceeds 200 particles per cubic centi meter of air, the rock drill is put out of commission.

All tips are provided with water sprays and are made to down cast and the dust is collected in flannel bags or saw dust filters which are fixed in the suction side of the fan which induces the down cast current in the tip by means of fan pipes let into it. All the broken rock in the stope face is wetted before lashing is done. An extra water hose is used while marking the holes. At the time of blasting in the shafts, winzes, rises and drives, water blast is turned on to allay the dust. The water blast is tested by an Inspector of Mines and the period of interval after blast before re-entry is fixed by an Inspector of Mines after sampling the air and counting the dust particles. As a general rule half an hour's interval is enforced but exemptions to this rule are also granted if the blowers and suction fans are very efficient and the dust count warrants it.

Dust particles of 2 microns and less are most injurious as they are easily absorbed by the lungs. These are invisible as the number per c.c. is too small. Fine dust injurious to human being is not ordinarily produced by nature but artificial methods are the soul factors in producing harmful dust. Large quantities of fine dust are always produced by falling rocks and when rock is bored by a steel bit which hits the rock many times per second. Blasting is another source of fine dust in the mine. This fine dust settles very slowly and 2 micron silica particle will take 15 minutes to drop one foot.

Removal of dust.- Various kinds of filters, such as flannel bags

bags, saw dust, and electrical precipiters are used to catch the fine particles of dust that are carried by the air. Flannel bags of close texture catch the fine particles effectively as they have to pass through the fine hairs which act as obstructions. These bags have to be renewed once a fortnight or earlier when the panes become clogged and the air flow through them is reduced. Great care is taken in taking them out to prevent the dust getting back into the air. These bags taken in closed bags or boxes to surface. Saw dust filters are treated in the same way but it is easy to remove them as they are in trays. A really good dry flannel filter will remove 99% of the fine dust. A high speed fan also removes dust in one effective way by carrying 30 - 40 of the dust through it. Dust particles are thrown together by the turbulent air and coaglate and secondly they are thrown against the casing etc. where they stick. If air containing harmful dust in suspension is diluted by fresh air which is dust free, the number of particles per c.c. will be reduced and the harmful effect of breathing such air is decreased. In the gold mines of the Witwatersrand, ~~and~~ fresh air is blown into the working face and the dusty air is sucked away and a combination of both the methods is used in many places.

Electrostatic Dust Precipitation.- This method is regarded as the most effective means of catching very fine dust. At the Nourse Mines an experimental plant has been erected at the 31st level No.1 A Incline Shaft. This consists of a series of zinc plates 4' x 10' long in the direction of the air flow, fixed at 12 ft. centres with bare copper wires suspended vertically at frequent intervals midway between the plates. In operation, the dust particles are ionised in the high potential field 75,000 volts surrounding the bare wire conductors and are deposited on the adjacent plates which are maintained negative. When they become heavily coated with dust, they are cleaned, once a month or much longer depending on the concentration of dust.

Measurement of Dust Particles.- There are three kinds of apparatus used for measuring the amount of dust in the air - the sugar tube, the Konimeter and the thermal precipitator. The first two are impinger forms of taking dust spots but the thermal precipitator which works on the principle that dust in the air is repelled by a hot body and deposited on the nearly cold surface is the most efficient of the three instruments.

Thermal Precipitator.- This apparatus consists of a thin wire placed between two glass surfaces. The wire is heated electrically and when the dusty air is sucked over the hot wire all the dust is deposited on the glass surfaces in the form of two sharp lines. The deposit obtained after treatment is examined under the highest power of the microscope and the number and size of the particles are counted. This instrument catches all the particles between the sizes of 5 microns and 1/10 micron. This instrument is strong, compact and easily worked and may be used to find the average dust condition over a period of many hours. The thermal precipitator catches all the fine dust whereas the Konimeter catches only a fraction of it. The number obtained by the thermal precipitator may be many times more than that obtained by the Konimeter but the counts of the coarser dust may be similar. This instrument enables the location of the dangerous dust in the Mines.

Konimeter.- Two forms of jet or impinger type konimeters are in use on the Rand. Kotze Konimeter is used by the Department of Mines and the circular Konimeter by the Chamber of Mines. The latter is more efficient as the chances of contamination are less owing to the glass plate being enclosed and rotated mechanically and larger number spots can be taken. Both the Konimeters work on the same principle. Air from a nozzle 0.6 millimeter diameter at outlet is made to impunge at high velocity on an area equal to 16 millimeters diameter of a glass slide, mounted 6 millimeters in front of the nozzle. The glass slide is coated

with

with a very thin film of glycerine jelly to catch the dust. The suction pump for the air is designed with a capacity of 5 c.c. and the piston is spring loaded so that the suction rate is automatic and operated by a trigger release.

The harmless organic substances and carbon particles are removed by immersion in dilute hydrochloric acid and ignition in g gas muffle on electric furnace and the remaining particles are examined under the microscope under the dark field illumination only and with a magnification of 150 diameters. The number of particles are counted with the aid of sectoral rulings and expressed as a total per c.c. The safe limit of particles per c.c. is c considered as 100, but this can only be taken as a relative value as 50% harmful particles are not caught by the Konimeter slide.

Notes on the practical work involved in connection with the determination of Dust in Mine Air, by means of the Konimeter.

The Circular Konimeter which is a modified form of the Kotze Konimeter is used for taking Dust Samples.

The cost of this instrument, with one slide, is £ 17-10-0d approximately (South African currency).

Microscope: The make of Microscope most widely used on the mines is the Zeiss.

Proper conditions requisite for counting dust particles on Konimeter slides under dark ground illumination:-

Eyepiece	.. ..	X 15
Objective	.. ..	16 m/m apo.
Tube length	.. ..	160 m/m
Condenser	.. ..	Abbe N.A. 1.2
Condenser Stop	.. ..	9 m/m
Okular Micrometer	..	18 degree sectors

In the eyepiece is placed the Okular micrometer with two ruled 18 degree

degree sectors: the total particles counted in the two sectors X by 2, give particles per c.c. (the Konimeter capacity being 5 c.c.). The above combination gives a magnification of 150 diameters.

LIGHTING:

(1) Source of Light. 100 Watt, half-Watt, gas filled, half frosted lamp, placed 9 inches from the mirror and 4 inches above the table.

(2) Mirror. The plain side of the mirror is used and so adjusted to give the maximum illumination.

CONDENSER FOCUS: The Condenser is focussed on the spot in the following manner:-

The dust spot is first focussed under dark ground conditions, and the Condenser stop then removed. While looking through the microscope the condenser is then racked up or down until a mark previously made on the surface of the frosted globe nearest the mirror, is sharply focussed. The condenser stop is then replaced and the spot counted.

PREPARATION OF SLIDES:

(1) The glass slides must be carefully selected, and those with faulty surfaces rejected.

(2) Microscopic glycerine jelly should be used as an adhesive. It is very important to spread the film as thinly and uniformly as possible.

(3) If the ignition method is adopted, heat-resisting glass slides must be used, and the side on which the spots are impinged must always be used for future work, as the underside which comes in contact with the brick tile will become contaminated.

Over-heating will have a tendency to fuse the spots on the slide, rendering it useless for further operations. This can be avoided with care.

The

THE TREATMENT OF KONIMETER SLIDES:

The method of treatment is as follows:-

After a preliminary examination of the slide under the microscope, the glass slide itself is detached from the brass ring.

Holding the slide over a porcelain dish, a few cubic centimetres of warm dilute Hydrochloric acid are poured very gently on to the centre of the slide, allowing the acid to flow quietly over all the dust spots which lie in a circle towards the edge. (Strength of acid used = 1.08 Sp.Gr. made up of pure strong H.Cl. and distilled water, in equal proportions).

The slide is then washed several times by immersion in basins containing boiling distilled water, and drained off quickly.

By these means, any water residue salts - sodium chloride, calcium sulphate, etc. (derived from atomised mine water) are entirely removed from the dust spots.

The next step is to ignite the slide in a small gas or electric muffle. The slide is placed on a smooth, ground, fireclay tile in the muffle (cold). The temperature is not allowed to rise above a dull red heat (approx.1050° F.); the slide is allowed to cool in the muffle. In this way all the carbon particles (derived from the acetylene lamps and candles used underground) with which the slide might be contaminated are entirely eliminated. The slide can now be transferred to the stage of the microscope, and particles counted.

If the underground conditions are free of Water Residue salts and carbon, the Konimeter slides can be directly used on the microscope, without any of the previous treatment stated.

Notes

NOTES ON THE GRAVIMETRIC OR SUGAR TUBE METHOD, FOR THE DETERMINATION OF DUST IN MINE AIR.

Sugar Tubes: These thick-walled glass tubes are 5 inches in length by 1¼ inches in diameter.

2 rubber corks are fitted to each tube, the upper cork solid, the lower cork bored to carry a small glass tube, ½ inch in diameter. On the lower cork rests a moderately thin layer of cotton wool.

Over this cotton wool pad is a column of pure sugar crystals, approximately 40 grams in amount.

The sugar used is Tate and Lyle's - "Mineral Water C", and is of such a size that it will pass a ten mesh sieve, and remain on a 20 mesh Sieve.

The half-inch glass tube is connected to a double acting Suction Pump, by means of 6 or 7 feet of stout walled black rubber tubing.

Capacity of Suction Pump: The Capacity of the pump per doubl stroke of the piston, is a little over three litres. (One stroke up and one down, constitute "a double stroke")

With the suction pump in good order, 100 double strokes correspond to one third of a cubic metre of air, drawn through the column of sugar.

(The upper or solid rubber cork is of course removed during the taking of a dust sample and subsequently replaced).

The pump requires lubrication occasionally, and should be calibrated at regular intervals against a Standard Wet Meter.

Taking a Dust Sample: The taking of a dust sample (usually one-third of a cubic metre of mine air) should occupy 8 to 10 minutes, so that the rate of pumping must not be too fast. The rubber tubing which connects the sugar tube with the pump, should never collapse during the operation of taking a sample, otherwise the vacuum formed will cause leakage of air at the ball-valves of the pump.

The sugar tube is held about on a level with the mouth of the

the machine boy, say, at the face of a drive; and at such a distance away, as not to be contaminated by any splashes from the Drill.

The sugar-tube acts as a Filter. The sugar crystals become moist and sticky after the first few strokes of the pump, due to the humidity of the underground mine air.

Treatment of the Sugar Tube Dust Sample in the Laboratory:

The tube is cleaned externally, with a damp rag. A "Whatman" (No.42, 15 C.M.) filter paper, is placed in glass funnel. These filter papers are made by W. & R. Balston Ltd., Kent, England.

A screen is then set, to rest inside the filter paper. (This screen consists of a brass truncated cone, the base of which is made of a small circle of the finest phosphor-bronze wire screening, 350 holes to the linear inch, or 122,500 holes to the square inch. This screening allows particles of a size less than 35 microns to pass through. The object of the screen is to eliminate any coarse particles which might have fallen into the sugar-tube, during the taking of the dust sample; also wisps of cotton wool possibly adhering to the lower layer of sugar crystals, or particles of rubber derived from the corks employed.

The rubber corks are removed from the sugar tube. Any sugar cystals adhering to the cotton wool pad are detached. The sugar is allowed to fall out on to the screen and carefully washed out with hot distilled water from a wash-bottle.

The application of hot distilled water is continued until all the sugar lying on the screen has dissolved. The free use of hot water facilitates the speedy filteration of the sugar solution.

If the solution is syrupy, or allowed to get cold, filteration almost ceases.

Finally

Finally the brass screen is removed from the filter paper, and is washed all round, inside and out with hot water. The filter paper is allowed to drain. Then the still moist filter paper is transferred to a Silica crucible, pressing the paper down with clean fingers. The crucible is placed over a bare Bunsen flame and allowed to remain there until the organic matter of the filter paper has been entirely burnt off and only mineral dust remains. (20 to 25 minutes is usually sufficient).

The crucible is removed to a dessicator, by means of steel tongs and allowed to cool.

Weighed on a Chemical Balance the mineral residue from the crucible are swept out with a camel's hair brush and the empty crucible reweighed. This latter weight is deducted from the former, which leaves the gross weight of the dust. Now the weight of the "Blank" is deducted and the difference is the nett weight of mineral dust obtained from one-third cubic metre of mine air. Multiplying this result by 3 yields the weight of dust, (expressed in milligrams) per cubic metre of air.

Blanks: Ten ordinary freshly filled sugar-tubes are drawn at random from stock and put through just as if they represented dust samples.

The average of the ten resulting weights obtained, constitutes the "Blank" for the time being

Each time the automatic sugar-tube filling device is recharged with fresh sugar, a new set of ten tubes are put through.

The weight of the "Blank" at the Chamber of Mines dust sampling laboratory usually run about .0007 gram or 0.7 milligram.

Heat Stroke.

Lashing, tramming, drilling waste packing etc. is done by the natives. It is only among the natives that fatalities due

to

to heat stroke have occurred. The European miners whose duties are only supervising occasionally collapse but no fatal ca cases have occurred.

The temperature gradient on the Rand is remarkably low ~~being boring~~ only 1°F. for every 200' - 220'. In Great Britain it is 1° F. for 60' - 70'. In mine I at a vertical depth of 7500 ft. the rock temperature was found to be 99° F. Because of this low geothermice gradient, the rise in the air temperature by adiabotic compression is relatively more important. It is therefore impossible without some form of artificial refrigeration underground to attain atmospheric temperatures more than a few degrees below rock temperature. These temperatures would not be excessive from a physiological point of view of it were nr not for the factor of humidity. The methods used for allaying silica dust for combating silicosis involve the copious use of water with the result that the air in the stopes where hard work is done usually is all but saturated. There is seldom more thar a degree or two between the dry bulb and the wet bulb thermometric readings. Unless very free air movement is provided wet bulb temperatures of 86°F. or over throw a great strain on the cooling mechanism of the body and strenuous work easily results in heat stroke in the unacclimatised.

Symptoms.- Towards the end of the first or second shift of lashing in a hot stope the boyx feels thirsty and complains of being tired. Complaint of fatigue may be followed by obvious weakness and the boy may stagger and fall down. In a number of cases, moniacal running about and struggling takes place and the boy has to be forcibly tied to a stretcher. Vomitting generally occurs. Occasionally the skin is described as hot and dry. The boy is hurriedly taken to a place with good air movement and lobelin may be injected by a boss boy or European Official. The patient is sent up to hospital as soon as possible. In most of the fatal cases the patient on admission

admission is unconscious with clonic contractions and twitching of muscles and an axillary temperature of 107° or 108°F. Usually he dies within a few hours. Occasionally there is some improvement death occurring some days later from lobar pneumonia. In these latter cases, the condition might conceivably have been one of impending pneumonia precipitated by the work in an atmosphere with low cooling power.

The boy is generally a robust young man of about 25 years of age.

Seasonal Distribution.- Although there is very little variation in the temperature of the air at deep levels, most of the deaths occurred in summer months. This can be most readily accounted for on the assumption that heat stroke is an auto intoxication due to the impairment of the excretary organs such as the kidney and liver and the increased production of toxic substances at high body temperatures. In the winter months, the daily cold periods spent on the surface allow of the complete elimination of such toxic substances.

Tribal Distribution.- Natives from the Portugese territory are least susceptible to heat injury. Basutos showing the greatest susceptibility. This is in keeping with the climatic conditions of their home areas. In Mozambique, the conditions are tropical with a hot humid atmosphere. Basutoland is situated at a high altitude with a cold dry climate. It had been variously suggested that natives harbouring parasites such as Malaria, Ankylostomiosis would be more likely to suffer from the break down of the heat regulating mechanism.

Distribution according to nature of work:

Mortality engaged in lashing	..	110 per 10,000
tramming		80
machines		10
other work		29

Underground atmospheric conditions.- Temperatures taken at all the working places where fatal cases occurred showed seldom

more

more than a degree or two difference between the dry and wet bulb readings. Fatal cases occurred in places of wet bulb readings of 86° F. and over. The lowest wet bulb temperature was 82° F. and highest 93° F. Wet Kata readings were obtained and they were under 7.5 millicalories per square centimeter per second; the highest being 11.1.

Acclimatisation.- The tribal distribution of these cases suggests a greater susceptibility on the part of natives born and reared in cold dry areas. This is due to inherent lack of acclimatisation. Analysis of the mortality figures bring out further extreme importance of temporary acclimatisation acquired underground. This is fully realised in all the deep mines. As far as possible efforts are made to allow the recruit to get acclimatised to the low cooling powers of the atmosphere at deep levels before putting him on to strenuous work in a hot place. He is usually required to serve a probationary period of a fortnight in a specially supervised gang where over exertion is prevented for example by issuing only one shovel for two boys. Collapses occur both during probation and immediately after. It will be seen that the boys collapse while serving their first or second shift underground.

A period spent in hospital might render a boy susceptible to heat injury, either by removing temporarily acquired acclimatisation or because of incomplete recovery from a febrile condition.

Heat Chamber: City Deep Ltd.- This chamber is situated in the Native Hospital and all new recruits are subjected to a heat tolerance test in this chamber in which they do lashing work in a saturated atmosphere of 95° F. The duration of the best is one hour and the native's temperature is taken after half an hour and again after the hour.

Acclimitisation period is decided as follows:-

4 days: Natives with a final temperature of 100.6° or under with a rise in temperature of 2.6° or less.

7 days: Natives with a final temperature of 100.8° F. to 101.6° F. or a rise of 3.6° F.

14 days: Natives with a final temperature of 101.8° F. or over or a rise of 3.8° F.

The foregoing standardisations are the result of long and methodical investigations during the period 1932 to 1934. An acclimitised native has a definite advantage over the new recruit as his initial body temperature and pulse rate are lower and increase when working in hot and humid atmosphere is less. His body has also learnt the art of sweating under control and profuse wasteful sweating does not take place. After a series of experiments a temperature of 100.6 was accepted as definite acclimitisation. The heat intolerant natives are those whose final temperature becomes 102° or over and majority of them become acclimitised after a few days.

The first shift worked underground in a hot place is the critical shift and thereafter the danger decreases rapidly.

East Rand Proprietary Mines: Heat Chamber.- This consists of a large room inside of which four 4" steam pipes are run round the walls. The floor is partitioned into four compartments. Twenty five boys on one side lash rock from one compartment into another in the first half hour and back again in the next half hour. Another set of 25 boys do the same thing simultaneously with the other two compartments.

The boys' temperatures are taken before the test, after the first half hour and again at the conclusion of the test, half an hour later.

The temperature 3 ft. from the roof has been maintained at 104 - 106° F. giving a temperature 3 ft. from the floor of 92°- 94° F. The result is that 50 - 60 % of the boys recorded

a

a temperature of 102° - a rise of 4° at the end of the test. Any native recording temperature of 102° F. or a rise of 4° at the end of the first half hour is warded in hospital for a few days and then retested - almost invariably successfully. Any boy recording these figures at the end of the test is given 14 days acclimitisation in selected places. The rest are given 7 days acclimitisation.

Since the introduction of this high temperature test, only one native who underwent the test has been reported with heat stroke.

Underground Acclimitisation: New natives are generally sent down to selected stopes in pairs. They have red armbands to indicate that they are for acclimitisation. The stopes selected have a wet Kata reading of 6 or more. Drinking water is supplie Here the boys do light lashing or sweeping work, two boys to a shovel in charge of trained boss boys. Rest is allowed and the boys are not hurried.

There were 20 cases and 8 deaths in E.R.P.M. during the year 1935. The non-fatal accidents revealed bad conditions.

The following method of dealing with new natives and natives returned from hospital for the Acclamatization and training of underground natives in Crown Mines, Limited has been adopted with a view to preventing heat stroke and accident cases and increasing the efficiency of natives employed underground:-

New Natives.

Compounds.- All new natives have the various dangers met with underground explained to them through experienced natives at the Compounds, and it is essential that the Compound Managers personally and at frequent intervals see that the instructions is properly given.

At Shaft Heads.- Where surface training schools are provided

provided, all new natives must be taken through these schools by the Native Supervisor and have the underground processes explained to them and be informed of the names of the various tools, materials, supports, etc., in common use underground.

Underground.- Certain places known as Training Schools must be set aside in each Underground Manager's Section for the training of Natives. These places are to be such that they can be considered to be safe and unlikely to be subject to pressure bursting. They should be well ventilated but not especially cool, and provided a wet bulb temperature of 85° F. is not exceeded, conditions can be considered reasonable. Light work in relatively high temperatures is greatly to be preferred to relatively hard work in moderate temperatures.

It is not intended that any particular limitation shall be placed upon the number of training stopes set aside in each Underground Manager's Section, and where the Manager finds it is more convenient to establish training schools in excess of one per Underground Manager's Section, there is no reason why they should not be so arranged, but generally it will be found that a properly organized fairly large training school can be more easily and efficiently supervised than a number of small ones.

Underground Instructors.- Each training school must be placed in charge of a "Native Instructor" who is an experienced European Ganger. He must be a patient, sympathetic person with a reasonable knowledge of native languages. As it is necessary that in the absence of the Ganger the work of the shcool should be carried on without interruption, there should be sufficient natives always under training to warrant the employment of a second European as assistant in it.

Sufficient experienced natives of various tribes and a native interpreter, who are able to instruct the natives in the various processes, should be employed in each training school.

All

All these natives will be qualified Boss boys holding Fi: Aid certificates, and they should be the best that can be obtained in the section and receive a lightly higher rate pay than the ordinary boss boy. These boss boys must not make the natives under them work too hard and they must re to the Native Instructor immediately any signs of distress any native. They must also receive special instruction in regard to the signs of heat stroke and immediate treatment before actual collapse has taken place.

TRAINING.- So far as practicable, old natives returnin to work will be put on the same class of work as when they le the mine. New natives will be trained in accordance with the probable requirements of the mine, and where possible, in accordance with their wishes.

When the Native Instructor goes on shift he will receive any new boys from the Native Supervisor and escort them to the training school and allocate their work. On the way he will instruct them how to enter and travel in cages and point out possible dangerous practices whilst walking in haulages and levels.

The following arrangements are to be observed in regard to training in the various processes.

Tramming.

No new boy may be put on tramming until he has completed six (6) shifts and then only on intermediate tracks where the size of the car does not exceed 10 cu. ft. until he has completed 12 shifts, when he may be placed in tramming work connected with the training school for a minimum period of 6 shifts, after which he may be transferred to his regular work.

Shovelling.

Only one shovel shall be supplied for each two shovelling boys employed in the training school, so as to ensure that these boys are not overworked.

Machines.

No new native shall be allowed to work machines until he has completed six (6) shifts and then three natives shall be employed on each machine instead of the usual two. The three natives shall work the machine in rotation.

Timbering

Timbering, Stonewalling and other work.
New boys employed on these processes must not be pressed and should be allowed rest periods. Generally at least three natives should be employed where two can do the work.

Period of Training.- All new natives must be employed in the training school for a minimum period of 12 shifts. Old experienced natives returning to work shall spend a minimum of 6 shifts in the training school. Locals who have been out of mining work for a maximum period of 14 days need not serve any acclimatisation period, but if they exceed that limit, they must spend a minimum of 6 days in a training school. The native complements of the training schools will depend to some extent on the number of new natives arriving, but the Native Instructor should be satisfied that a native is reasonably well trained and acclimatised before he is sent out.

Tickets.- The Native Supervisor will stamp the necessary number of tickets, in accordance with the preceding paragraph, in each first book with the letter "P" in red ink, signifying "probation" and no such native shall be employed anywhere except in the training school until the necessary shifts have been worked.

Should the Native Instructor consider that the period is too short in any particular case, he shall notify the Native Supervisor as to the probable extra shifts required, and he shall stamp extra tickets accordingly.

Natives Returned from Hospital.- The Medical Officer shall render a daily return of natives discharged from Hospital to the Chief Compound Manager, shewing the period and class of light work he recommends that each native shall be put on, as follows:-

A. followed by No. of days = Light underground work, or
B. " " " = Surface Work, or
C. " " " = Light Surface Work, or
D. = resume previous work.

The

The Compound Officials will stamp the Native's ticket book "A" or "B" or "C", in red ink, for the number of shifts recommended for light work in accordance with the Medical Officer's recommendation.

General.- No person, other than the Native Instructor, shall work any native whose ticket is marked with "P" in red ink. The Native Time Office will immediately notify the Compound Manager and Underground Manager concerned of any such ticket which comes from any other Ganger. Natives, whose tickets are marked "A" or "B" or "C", in red ink, shall only work on special light jobs or in the training schools.

A rest period of 30 minutes shall be allowed in the middle of each shift.

An adequate supply of drinking water shall be available at each training school.

An adequate supply of lime juice and salt solution for drinking shall be supplied at each training school and the natives should be persuaded to drink it.

First Aid boxes containing Lobeline should be provided, and special efforts should be made to see that all wounds, however slight,. are properly dressed.

Instructions in case of heat stroke must be posted at the Native Instructor's box.

The symptoms and First Aid treatment are as follows:-

Symptoms.- The earliest symptom, which might persist for some hours before the attack actually occurs, is a desire to pass water frequently with or without a feeling of dizziness. But an attack often comes on very suddenly.

The symptoms of a well developed attacked are:-

(1) Unconsciousness, with or without delirium.

(2) Spasms of limbs or convulsions.

(3) The skin is usually dry, but may be wet. It usually feels hot to the touch

(4) There may be frothing at the mouth.

(5) Difficult breathing.

(6) The veins about the neck become prominent and throb.

First-Aid Treatment.

(1) The patient should be removed as rapidly as possible to a cool and airy place and the whole body should be sponged with as cold water as can be obtained at the same time rubbing the skin with hands or a towel and fanning. Iced water or pieces of ice wrapped in a towel should be used if obtainable.

(2) A dose of "stimulant" (Spirits of Ammonia) should be given.

(3) An injection of "Lobeline" if available, should be given.

(4) If breathing is difficult or laboured, artificial respiration should be performed.

(5) The patient should be removed to the Hospital as soon as possible.

The following methods are adopted for Heat Stroke Acclimatisation of the Probationary Gangs in the Robinson Deep Limited:-

The probationary gangs are to be worked in stopes representing ordinary conditions under special Boss Boys who have instructions to superintend them with care, and to keep each individual native under close observation. The gangs are to be employed on sweeping and reclamation work. ~~They must not be employed on sweeping and reclamation work~~. They must not be intermingled with other gangs, and must not be employed on any working face. Each native is to be provided with a red armlet, which is issued each morning and returned at the end of the shift. When drafted to these gangs, the number of tickets to cover the probationary period allotted are to be stamped "Probation", and a record shall be kept showing the native's number, previous service probation period allotted, section where serving probation period, date of completion of probation period and section to which finally allotted.

When a ticket is lost and it is necessary to issue a duplicate, reference must be made to this record so that the duplicate can be stamped "Probation" for the days to complete the probation period. Care must be taken that the full period is worked underground, and any shifts missed during the probation period must be made up.

New Natives:

All new natives shall be detailed as follows:-

1. Natives who have never worked underground on the Witwatersrand. These are to be given a minimum period of 12 days in a probation gang.
2. Natives who have previously worked underground on the Witwatersrand.

These

These are to be given a minimum period of 6 days in a probation gang; except such natives as have previously worked at the Turf Shaft section who have not been absent for a longer period than 6 months, and are returning to their old class of work. These may be excused the probationary period. This exception does not refer to natives returning to lashing or tramming except in the case of boss boys. All natives for lashing and tramming shall serve a probationary period of at least 6 days.

Natives ex Hospital.- All natives who have been discharged from Hospital shall be paraded. Each case shall be considered individually by the underground Native Supervisor, who shall allot probation periods according to their service underground, hospital record, and general physique.

All natives, without exception, who have suffered from heat stroke underground, will be put on minimum of 9 days light work, and may, at the Underground Native Supervisor's discretion, be either sent back to their section, or transferred to another section of the mine.

Natives who have had less than 3 months work underground and have spent more than a week in hospital owing to sickness are to be given a minimum of 6 days in a probation gang or on light work.

Natives on light work shall wear red armlets and their tickets shall be marked "light work" for the number of days allotted. Light work may be done on all classes of work except machine drilling, lashing or tramming.

Silicosis.

When very fine silica dust is inhaled into the lungs over a long period, it tends to induce the formation of fibrous tissue causing various degrees of disability. This condition also creates a predisposition to tuberculosis and this combination is generally fatal. About the years 1902 and 1903 the dangerous effects of the mine dust were realised and it was found that 16.5 % of the people working rockdrills dry had died of this disease. In 1903 the first report of the Miners' Phthisis Commission was published and the Government regulations to prevent silicosis came into force. The principle methods in use for the prevention of dust are: wet drilling, control of the types of drills, wetting of all underground rock surfaces as well as broken rock, regulating of blasting, effective ventilation and provision of air filteration plant.

Since 1916 medical examination of all white candidates for underground work has been done and only about 40 % are passed fit. Thereafterwards they are examined periddically every six months to detect cases of silicosis. Natives are also periodically examined by the mine medical officers. As a result of all these measures, the incidence of silicosis has dropped from 3.1% in 1918 to 0.9 in 1933-35.

Mining Industry provides compensation to silicotic persons according to Government Acts. The compensation varies from £ 400 to £ 3500. Since 1919 the Gold mines have contributed £ 800,000 a year to this compensation fund. In addition they have paid over to a special trust £ 4,315,618 in respect of terminal liabilities upon closing down.

Compensation to natives is paid through the Director of Native Labour.

Native

Native Labour.

The Witwatersrand Native Labour Association recruits all the labour required for the mines on the Rand. The Depot at Johannesburg accommodates 2000 natives and includes one of the most up to-date hospitals. On arrival at the Recruiting Depot each boy is given an identity disc. His clothes and belongings are disinfected. They are then medically examined and vaccinated and xrayed. This is the second medical examination, the first having taken place at the mofussil recruiting depot. A few temporarily unfit for underground work are given surface work Then they are sent to the various mine compounds for registration A contract boy is enrolled for a period of 6 - 9 months but a voluntary boy is taken on for a period of 4 months. At the pass office, each boy's finger print is taken and an impression forwarded to the mine. Over 285,000 natives are passed through the W.N.L.A. every year. Over 20,000 recruits are dealt with every month.

W.N.L.A.Hospital. The staff consists of 7 doctors 8 white nurses and 53 native orderlies. There are 27 wards and 400 beds. Specialists attend for all kinds of diseases. All artificial limbs are supplied free. The interest taken in the patient does not cease with his discharge to the Kraal. A native who complained that the doctor had not done his work properly was brought back again, all expenses paid, operated and sent back 800 miles to his home.

Natives are taught how to breath for all natives breath through their mouth and for underground work it is essential that he should breathe through the nose.

Training Boss boys: Promising natives are trained to become boss boys on the recommendation of the shift boss and approved by the mine captain. For two months he is given daily lectures by native instructors under the supervision of a white man. Practical demonstrations are given and dangers of live wires

wires, loose hanging etc. brought home to them in the scho at the shaft top where a model tramway with live wires and stope with supports are fixed up. Picks, shovels, lantern hard hats etc. are kept in the school and the proper way of handling them shown. Boys for promotion are asked to fix a chute or pigstye in the model stope in the presence of the sh boss before selecting him. The candidates are shown a stope face with the misfire marked and asked to show the position of the hole to be drilled.

Accidents. When the boys come up, they are made to hold out both hands to be examined for scratches as the acid water in which they work may cause it to become septic. Boys with severe cuts are sent to the native hospital for treatment. Iddine is not used as it shocks the nervous system and other disinfectants are being tried. The boss boys usually hold first aid certificates and render first aid underground. First aid stations with all the necessary appliances are provided at all the levels.

Mine Compound (City Deep, Ltd.)- Accommodation is provid in this compound for 4,000 boys. There are a number of lar rooms each of which accommodates 54 boys. There are two berths in some rooms. New rooms are being built for only 24 boys in each. There are a number of Police boys in the compound to control the mine boys. Each boy is weighed and examined by a doctor on entering the compound and again at the end of each month. If there is a loss of 5 lbs. in weight he is sent to the hospital for observation. Each boy is given a tunic and a blanket and a carbide lamp. He is given a number and the history of his service is maintained. Hot and cold shower baths are provided in the compound and a fire in the room. They are given bread and cocoa in the morning and mealy meal and vegetables on return from work. All food is cooked by steam under the supervision of a European and distributed at the cook

house

house under the supervision of Police boys. Their country drink "Mohai" is also made in the compound and supplied to them. Fish is given two days in the week and mutton on another two days.

The following is the average menu:-

Morning - 6 oz. of bread, porridge, coffee or cocoa.
3 P.M. - 24 oz. of mealy meal
3 oz. of beans
5 oz. of soup
3 oz. of fat.

Pint of beer - a day - Kaffir beer consists of kaffir corn and yeast and contains 2 % alcohol - (this percentage should not exceed 2½).

3 quarts of Mohai made from mealy meal (12 tumblers)

Payment is made in the compound by taking their left thumb impressions. They start on 1 sh. 6 d. a day and go up 1/8 in two months and finally to 2/- or 2/6. The machine boys who are paid according to footage drilled earn as much as £ 6 a month. Some of the educated natives act as interpreters and get about £ 7 a month.

Explosives.

Modderfontein Dynamite Factory.- It is situated 12 miles N.E. of Johannesburg and comprises an area of 11½ square miles. It lies in a valley surrounded by low lying hills all around. Since 1931 this factory is operating an ammonia synthesis plant for the manufacture of nitric acid. Sulphuric acid is also manufactured in the factory from iron pyretes. Ammonium Nitrate required for Ammon Gelignite is imported from England. Glycerine is also imported from abroad. The rest of the raw materials are obtained in the Union.

Ammonia Plant.- Previous to the building of this plant thousands of tons of sodium nitrate were imported from Chile every year for the manufacture of nitric acid. The ~~new~~ raw materials used

used for the production of ammonia are:-

(1) Coke (2) Steam (3) electric power (4) air.

Ammonia is produced by combining one part of nitrogen with three parts of hydrogen and the following is a brief description of the plant at Modderfontein. A mixture of producer gas and water gas is obtained in a special gas producer using coke, steam and air. By passing alternately steam and air over red hot coke produces gas and water gas reactions are carried out and their operation is automatic. This gas obtained from the producers contain a high percentage of CO and by causing it to react with steam more hydrogen is obtained in the hydrogen plant. The gas from this plant is compressed in a six stage compressor to 3000 lbs. per sq. inch, When ammonia is formed. The carbon di-oxide is removed in the compressors by injecting water at high pressure. The actual synthesis is carried out in a special converter at 550° c. The gas produced is cooled to form the ammonia solution which is used in the oxidation plant to produce nitric acid. Nitroglycerine is manufactured in isolated huts in a valley with all the necessary precautions. Then it is mixed with gun cotton to form a jelly which is transported to Robert's mixer where wheat flour is added as a dope. Mixing is done mechanically in isolated buildings in wooden pans and wooden rollers, the motor supplying power being erected below the building. After mixing the product is ready for making cartridges which are done either by hand or mechanically. The cartridges are either 4" or 8" long and are put into 10 lb. packets which are packed in 50 lbs. boxes made specially for the purpose in the factory. Aluminium coated nails are used and brass hammers are kept for nailing them.

The capacity of each room is painted on the door and not more than 2 or 3 persons work in each individual unit. Safety appliances are ready at hand to stop the machinery in case of emergency.

Ammon Gelignite: This explosive is eminently suited to the peculiar conditions obtaining on the Rand. In 1934 it was introduced to the mines as it was found to be slightly cheaper and yet little stronger weight for weight than the straight gelignites. The composition of the most popular strengths is given below:-

	Strength	
Constituents	60%	50%
Nitroglycerine	30.0	27.2
Nitro-cotton	1.0	0.8
Sodium Nitrate	-	12.5
Ammonium Nitrate	62.5	50.0
Wheat flour	2.0	4.0
Oat husk flour	4.0	5.0
Moisture	0.5	0.5

From the above it will be seen that the nitroglycerine content has been reduced when compared with the straight gelignites. The low percentage of nitroglycerine lessens the dangers attending upon the handling of the explosive cartridges. There have been no accidents on the witwatersrand during the charging of drill holes with ammon gelignite. This shows that it is less sensitive to shock and friction than the straight gelignite.

Ammonium Nitrate is very hygroscopic substance and every precaution must be taken to prevent its acquisition of moisture which renders it insensitive as an explosive. At the factory all 1¼", 1" and 7/8" diameter cartridges are wrapped and waxed by machinery and in this manner, the ends of the cartridges are effectively sealed and the whole stick efficiently water-proofed.

When it is first made it is softer than the straight gelignite so that in order to obviate deformation they are carefully stored on end. After about two days, it firms up and then becomes harder. High temperatures have softening effect

so

so that after a shift in the hot underground atmosphere there is little difference between the two types. If the cartridge is used on the day of delivery, there is a possibility due to its hardness of the wrapper becoming damaged when it is passed over a ridge in the drill hole during charging. Should this happen however and a smear of explosive be left on the ridge the danger of a premature explosion being caused by the friction of the charging stick is minimised on account of the following factors:-

(a) less nitrogylgerine is present in the smear.

(b) even if the ammonium nitrate was not immediately dissolved and rendered insensitive, it is less sensitive to shock and friction than the nitroglycerine content.

Another feature of this explosive is the liberation on detonation of ammonia which neutralises some of the resultant fumes and so makes the after atmosphere less dangerous and easier to render innoccuous.

Detonators.- The aluminium tubes required for making caps are imported from abroad. Lead azide and lead stephanate are made in the factory but a tetryl, a coal tar by-product, is imported. After the chemicals are purified the aluminium tubes are filled in the following order:

Tetryl a white powder is put in at the bottom and above it a layer of lead azide, a yellow substance is put in and above them, lead stephanate, a brown powder is put in and gently pressed by a special machine. These detonators are water proof. The filling process is carried on by machinery kept in closed rooms with walls 2 ft. thick with a glass window. The operator stands outside all the time and is safe even if a cap explodes while being filled.

Fuse

Fuse.- is imported from England or Germany. Before a consignment is landed, the Inspector of Explosives tests the samples and issues a certificate.

Capped fuses of required lengths are made in the factory and supplies to the mines. Wax or wood inert primers are also made for some of the mines.

Storage.- Several large magazines of 10,000 lbs. capacity are constructed by cutting into the slopes of hills for storage. All these magazines are inspected and approved by the Inspector of Explosives.

At the Modderfontein Factory great care is taken to avoid the effects of static electricity which is prevalent during thunderstorms. When a storm is brewing all work is stopped and the men are withdrawn from the several working huts. A great number of lightning conductors are fixed at frequent intervals all over the danger zone. As a person charged with static electricity caused an explosion of a cap filling hut, all the door handles are earthed and the floor covered with lead sheathing. A gold leaf electroscope is also kept in the room to enable persons entering to test themselves before going into the room.

Transport.- Specially constructed motor lorries approved by the Inspector of Explosives are used to convey explosives from the factory to the mines. The following are the special precautions drawn up by the Chief Inspector of Explosives regarding the Construction of Bodies and Licensing of mechanically propelled vehicles for conveyance of Explosives:-

1. No mechanically propelled vehicle may be used for conveyance of explosives unless specially licensed for the purpose by an Inspector of Explosives.
2. For the issue of the license, the following particulars will be required:-

(a)

(a) Make and Model of vehicle;
(b) Nominal carrying capacity, that is:-
Gross loaded weight of truck,
Gross capacity of chasis,
or Body allowance and nett capacity of chassis, according to the maker's specifications.

(c) Chassis weight on weighbridge in full running order with fuel, oil, water, tools and spare wheel complete.
(d) Wheel-base;
(e) Distance from centre of front hub to back of cab position (a body builder's diagram should be supplied if possible).
(f) Proposed internal dimensions of body and proposed details of construction;
(g) Make, size etc. of tyres fitted to all wheels;

The above particulars should be submitted before any particular chassis is purchased in order to avoid disappointment as regards the eventual quantity of explosives or other loads which the truck will be allowed to carry. From these particulars an estimate can be given in advance.

The following particulars will be required after construction of the body:-

(h) Total weight of finished truck on a weighbridge; Weight with front wheels on weighbridge; weight with rear wheels on weighbridge;
(i) Actual internal dimensions of body - internal length, internal width and height of sides above gratings if any;
(j) Distance from centre of front hub to a line through centre of internal body length;
~~Distance from centre of front hub to a line through centre of internal body length;~~
Distance from centre of rear hub to the same line (or from each rear hub if a six wheeled truck);

The actual loads allowed are calculated, firstly, from the capacity of the chasis and the body weight and, secondly, from a comparison of the weight carried on each axle with the tyre carrying capacity. The explosives load is 75 % of the non-explosives load.

3. All woodwork in the cab and body must be treated with a suitable approved material to render the wood fire-resisting. "PORCELLA" fire-resiting paint (Rely Metal Works, Johannesburg) has been found to be the most satisfactory. Failing this, the wood must be treated three times with a four per cent solution of zinc sulphate used liberally and allowed to dry thoroughly after each treatment. After zinc sulphate treatment, paint will not adhere unless an intermediate treatment

is

is given and red lead well rubbed into wood is recommended.

4. The wood sides of the truck must be at least as high as the centre of the top layer of cases of explosives to be carried;

5. The under surface of the body must be covered with flat galvanised iron. Edges and overlaps of this must be supported with 1" x 1/8" hoop iron, bolted through the floor. If desired, the upper surface of the floor of the body may be covered with metal plate but, in this case, loose wooden gratings must be provided to cover the floor and must be used when explosives are carried.

6. There must be no exposed iron whatever in the interior of the truck as used for explosives. If iron bands are placed on the side-rails, the sides of the body must be so made as to prevent explosives cases coming into contact with the bands. All bolts etc. must be pulled well into the wood.

7. Hard wood only must be used for the longitudinal and cross members of the body and the longitudinal members should be carried as far as possible into the cab.

8. The back of the cab must be of metal. In the case of petrol driven vehicles, there must be a space of full six inches between the back of the cab and a fire-screen, the forward side of which must also be of metal and the screen must be as high as the cab and as wide as the over-all width of the body. The rear face of the screen to at least the height of the sides of the body must be faced with wood. Heavy glass windows may be fitted in the back of the cab and in the screen but there must be no openings.

9. Brackets must be fitted to each side of the cab and each side of the rear end of the body for 18" square red flags

10. In the case of petrol driven vehicles, there must be an emergency petrol cock of the push and pull type fitted between the carburetter and the vacuum tank or between the main tank and the petrol pump, as the case may be. This must have a 3/16" steel rod fitted to it and terminating at a point convenient to the driver so that, from his seat, the driver may shut off the petrol by a straight pull on the rod.

11. Where the carburetter, petrol pump or any other fuel fitting is placed over the exhaust manifold or any part of the exhaust system, a shallow tray must be fitted under the carburetter, pump or fitting to catch any leaking fuel and conduct it by a copper pipe to a lower level than the exhaust system.

12. The petrol tank must be in front of the back of the cab.

13. A chemical fire-extinguisher of the carbon-tetra-chlorid or combined C.T.C. and FOAM type must be carried in the cab of the vehicle.

14. Only electric lamps may be carried.

15. In the cab, the body-builder must place a pocket of metal, wood or leather about 9 inches deep, four inches wide and ½ an inch thick to carry the driver's papers.

16. Only NEW TRUCKS can be licensed for explosives.

-: o :-

Sub-magazines on the mines: All these magazines are of a standard type with a floor space of 18' x 15' and are passed by the Inspector of Explosives to contain 500 cases of gelatine. No magazines are allowed to be built below the ground level. The walls consist of corrugated sheets outside and planks on the inside with space between filled in with cinder or ash. The

floor

floor and the roof are also planked and ventilators are provided The boxes are placed on the wooden floor and the height of the pile is not allowed to exceed 6 ft. The boxes are so piled that the date of the manufacture of the contents can be read easily to facilitate delivery in the right order so that no box is allowed to remain long in the magazine. As supplies are received twice a week, there is no need to store large quantities Special boots are kept in the lobby. A thermometer is kept inside and temperatures are recorded daily. It should not exceed 95° F. and if it goes below 45° warning is given to the underground officials. The explosives are issued in boxes and are not opened in the lobby. Explosives are taken underground twice a week and distributed to the miners who keep them locked in approved boxes.

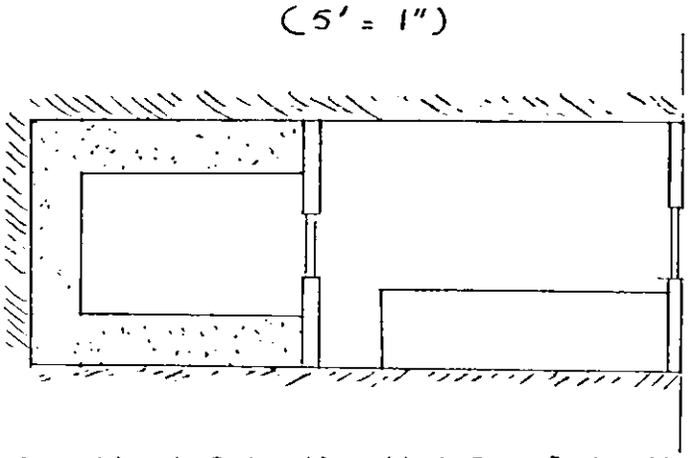
Detonator annexe is not built as capped fuses are generally used. These capped fuses are stored in a separate building which is not lined in wood as the magazines.

Earthen ramps, rising to the height of the eaves of the building is provided all round. Copper tape with finials are provided for protection against lightning. In some magazines, a separate pole of pipes is fixed just outside the magazine as a lightning conductor.

Storage of large quantities of explosives underground is not generally permitted. But in special cases like sinking of a large shaft an underground magazine to store a week's supply is permitted under certain conditions. One such magazine is in use at present at the 41st level (about 8000 ft. below) 15 B Shaft, Crown Mines and the following is its description:-

Underground Explosives Store - Crown Mines, Ltd., No.15 B Shaft (about 8000 ft. below) 41st level.

GROUND PLAN.
(5' = 1")



It is situated in the 41st level in the footwall of the main reef ~~under~~ / louder approximately 400 ft. - permitted to store 40 cases in order to store sufficient stock for week ends and in the event of blasting on two shifts.

The magazine is cut in solid rock, the sides and back lined in concrete and an arched roof 6'2" high - a well constructed timber partition dividing it into two compartments. All the compartments are completely lined in wood. The inner compartment contains three sets of wooden shelves 15½" apart for the storage of explosives. The concrete floor is covered with duck boards.

The outer compartment contains a wooden bench for opening the cases of explosives and transferring them to portable canvas bags.

Both the compartments have doors opening outwards locked with Yale pad locks attached to a hasp and staple.

A powerful electric light is to be fixed opposite the outer door in such a way as to throw light into both the chambers The danger signal of skull and cross bones is attached to each door. A thermometer has been hung in the inner chamber to indicate the maximum and minimum temperatures.

The chamber is ventilated by means of a compressed air jet blowing air into the inner chamber on the hanging wall side.

No

No electric cables are lights to be placed inside the chamber but a wooden mallet and a brass chisel are provided in the outer chamber for opening the cases.

Electric blasting is to be done. The primers are to be made up on a wooden bench placed in the same crosscut 30 ft. away from the magazine. An electric light will be suspended over this bench.

Permission granted by the Inspector of Mines with the approval of the Government Mining Engineer and the Chief Inspector of Explosives on the following conditions in addition to such of the provisions governing the storage and handling of explosives contained in the regulations.

(1) There shall be no water mains, air mains or electric cables so situated as to make access to the store difficult.

(2) The magazine room shall be floored with boards and the walls lined with ceiling boards. The distribution room shall also be floored with boards.

(3) The lighting arrangement shall consist of strong electric light shining into both rooms from without.

(4) Any ventilators shall be covered internally with brass wire gauze.

(5) Not more than 40 cases shall be in the magazine at any one time.

(6) The magazine and distribution room should be filled with good locks.

(7) The magazine to be in charge of a competent scheduled person who shall at all times retain the keys in his possession.

(8) The explosives shall be stored on wooden benches.

(9) Every case of explosives shall bear the date of entry into the magazine and issued in correct rotation.

(10) Only unopened cases shall be stored and only unopened cases issued from the magazine.

(11) Ventilation to be by means of a compressed air jet.

(12) A register of receipts and issues to be maintained in the magazine.

(13) A typed and legible copy of these conditions shall be kept posted up in the distribution room.

DIAMOND MINING IN KIMBERLY.

The blue ground containing diamonds occurs in vertical pipes, the depths of which have not yet been ascertained. Only one mine, the Dutoilspan mine is being worked at present by underground methods as the country rock above has caved into the old open workings.

A rectangular vertical shaft of 5 compartments has been sunk to a depth of about 1000 ft. at the edge of the pipe at a safe distance from the old workings. From this shaft, tunnels have been driven to reach the blue ground. Double tracks with an endless rope way have been laid in the main haulage levels. Drives have been put through the blue ground to reach the end of the pipe and tunnels have been driven completely round the pipe. Main haulages have been driven at every 600 ft. and the broken blue ground is run through chutes in the country rock.

Method of mining is known as sub level mining. ~~Sub~~ Sub levels are put out every 40 ft. and the blue ground between sub levels is stoped out by machine drilling and blasting. The broken blue ground is hand trammed to the several chutes in round tunnel and tipped to reach the haulage level. The waste filling of the old pipe is allowed to cave into the excavations caused by stoping the blue ground.

Skip hoisting is carried on from the shaft pockets and 6000 tons are hoisted in 8 hours. The shaft equipment and the hoisting arrangements follow the Rand Mining practice. The chute doors are operated by compressed air and the skips are filled

filled from a loading box which contains exactly the quantity required to fill one skip at a time.

Recovery: Diamond is imbedded in the blue ground without much adhesion and therefore can be easily liberated by disintegration. This is done by crushers and rolls. As diamond is of a higher specific gravity than the ground, concentration is effected by means of washing pans. In these pans, the lighter materials are all washed away and heavier concentrate containing the diamonds is recovered. This concentrate is passed over pulsator jigs which remove all materials lighter than diamonds. The concentrate from the jigs is passed over inclined tables smeared with grease and these tables are oscillated sideways with water running down. On this table diamond sticks to the grease while the other minerals pass off. The grease is then scraped off and melted down and the diamonds recovered.

Kimberlite.- This a volcanic ultrabasic rock filling ancient pipes vertically. These pipes occur in groups and 25 of them have been mined. These pipes vary in diameter from a few feet to over half a mile the latter being in the Premier Mine which has been closed down. In vertical section these are steep sided funnels. The Kimberly pipe has been worked to a depth of 3520 ft. as an open mine.

Diamonds are usually octohedral in form and cubes are uncommon. Rounded edges are general. They vary in size and cullinan 3025 carats equal to 1.37 lbs. was the largest that was ever found . (1 carat = 200 milligrams). The Union of South Africa produced 70 % of the World's diamonds in 1919 and 1920 and thereafter there was a gradual fall to 13 % in 1932. During recent years only small quantities are being produced and most of the larger mines had to close down for want of demand and increased production in other parts of the World.

COPPER.

Nkana Mine.

The Nkana orebody consists of a series of sedimentary beds folded into a syncline the lower members of which have been intruded by granite and pegmatite veins. Micaceous shales and argillaceous sandstones form the orebody. It strikes N. & S. and dips about 50° to the west. There are two distinct grades of ore, the hanging wall high grade and the footwall low grade. The hanging wall is a quartzitic argillite while the footwall is feldspathic sandstone with bands of conglomerate.

Copper occurs as bornite, chalcocite and chalcopyrite while cobalt occurs as carrolite. From surface to a depth of about 200 ft. the ore is highly oxidised to carbonates and this is not mined. Development is being carried out from a central vertical shaft 1700 ft. in depth. Ore is hoisted in 10 ton skip from the 6th, 7th and the 9th levels.

The mine is ventilated by means of three Aero Van Suction fans, capacity of 130,000 cu.ft. per minute each, placed at the collars of disused shafts.

Main haulage ways 12' x 12' are driven in the orebody for the length of the strike. Sub level method of stoping is the general practice. Two raises are put up in the ore body at convenient intervals from level to level and stoping commences from these raises. A box hole is made between these raises to form the ore pass. One of these raises is used as a travelling way from sub level to sub level. Jack hammers are used for breaking ground. All mining is done during day shift - drilling and blasting. Mucking is done during the night shift Payable ore in the present stoping areas extends for a length of 7000 ft.

All stopes having a dip of less than 50° are scraped by scraper

scraper hoists driven by 50 H.P. electric motors. Trolley locomotives are used to haul trains of 9 trucks each 180 cu.ft. capacity. The chute lips are operated by compressed air cylinders.

The principal minerals in the ore are Bornite chalcopyrite, chalcocite and carrolite - a copper cobalt sulphide - Cu Co_2S_4 and small quantities of native copper and its oxides. The ore is delivered direct from the central shaft bin to the primary crushers. From there it is passed on to cone crushers and vibrating screens which remove the minus 1" material. The undersize is conveyed by a belt conveyer to the mill bins over a weightometer. The ore is fed into ball mills and the discharge is pumped to Dorrclassifiers and the sands are returned to the ballmills for regrinding. The overflow from the classifiers is pumped to Bowl classifiers, the overflow from them is the flotation feed. There are 8 flotation cells. They make three products - rough concentrate middling and tailings which go to waste.

The concentrates are pumped to an Oliver filter plant. The cake which contains about 9% moisture is conveyed to the smelter bins.

The flotation reagents used are lime, pine oil Xanthate and sodium sulphide.

Smelters.- The concentrates from the filter plant is conveyed to the bins above the smelters. The pulverised cool and silica flux is also delivered to the top of reverbaratory furnaces. Each reverbaratory furnace is 90' x 26', lined with magnesite bricks 43 % alumina. The wet concentrate with fluxes are dropped into these furnaces by trucks. All air used for corobushion is preheated. Furnace temperatures range from 1300 to 1600° C. matte being 1200°C. and slag 1300°C. The slag is skimmed off in the front wall of the furnace and

conveyed

conveyed into the waste dump. Matte is tapped from the holes on the side of the furnace and taken by a ladle to the converter. Air for oxidising the matte is delivered through 1½" pipes and blown by two turbo blowers of 20,000 cu.ft. per minute at 20 lbs. pressure. Converter operation consists in oxidising the sulphur, iron and cobalt content of the matte, slagging the iron and cobalt with siliceous flux. Copper of about 99.5% purity is obtained. This copper is delivered to the anode furnace or to a holding furnace for casting into blister cakes.

During June 10,385 tons of concentrates were treated producing 2,311 tons of blister copper and 2,393 tons of anode copper.

Analysis of concentrate: H_2O - 8.7, $Si\ O_2$ 8.8, CuO . 67 Cu 47.54 Al_2O_3 2.26, Mgo 1.06, S 23.64 Fe 11.43 and Co 2.00

Slag. Cu 0.7 $Al_2\ O_3$ 8.6, Mgo 2.6 S. 0.15
Feo. 31.8, $Si\ O_2$ 38.9 Ca O 1.8 Co 3.3

Matte Cu 58, S.23.6 Fe 12.5 Co 3.7

Refinery.- Anode Plant - The molten blister copper delivered by the converters is conveyed to another furnace fired with pulverised coal. The anodes produced are 38" x 38¼" x 1½" weighing about 700 lbs.

Tank House.- The anodes are carried into the Tank House which has 416 tanks lined with antimonal sheet lead. The anodes and cothodes are spaced 4.3/8" centres. The electrolyte contains 4% copper and 17% free sulphuric acid and is circulated through the tanks. The cathodes are drawn after 18 days deposition and taken to the casting plant. After 38 days corrosion the anodes are removed and sent to the smelting house. The electrolytic copper is melted and cast into wire bars or ingots.

Roan Antelope Mine: Copper.

This was the first underground mine that was brought into production in the copper belt of northern Rhodesia. Chalcocite bornite and chalcopyrite are the predominating minerals

minerals. The ore reserves are estimated at 108,000,000 tons of 3.44 % copper. The minerals are finely disseminated throughout the well bedded metamorphosed argillacious sandstone and shale which vary in width from 10 - 45 ft. The ore body is an asymmetrical syncline and the outcrop is hair pin shaped. The greatest width is 2000 ft. and the depth 2,200 ft. There are no major faults.

A main vertical shaft has been sunk 180 ft. away from the orebody in the footwall. This shaft delivers ore directly into the coarse grinding plant, eliminating transport. The depth of the shaft is 1000 ft. The shaft is concrete lined and equipped with steel sets.

Sub-level method of mining as is practised in the Nkana mine is also carried on in this mine. The main haulage level is driven in the ore, close to the footwall side so that grizzlies are installed on the footwall of the stopes. The grizzly level is 35 ft. above the haulage level. The first sub level is driven above the grizzly level. The bottom of the stope is then opened out in the form of a cone from the footwall to the hanging The following sub levels are driven at intervals of 25 ft. in the orebody. Service raises are put up at intervals to connect the sub levels. Then holes are drilled in the sub levels towards each wall and benches are formed. Workmen stand on these benches and carry on further drilling. Benches are blasted singly or several at a time. Pillars are left at necessary intervals and no supports are used in the stopes owing to great widths and the walls are also sound. The pillars are subsequently reclaimed.

On dips greater than 40° the ore runs down the shale footwall but in low dips, scrapers are used. Ample ventilation is provided by shafts and raises. A fan with a capacity of 25,000 cu.ft. per minute has been erected on the top of an old

shaft

shaft to exhaust the foul air. Overhead trolley locomotives and storage battery locos are in use for transporting ore underground.

The metallurgical plant is similar to the Nkana plant except the electrolytic refinery.

LEAD.

Broken Hill - Zinc & Vanadium.

Broken hill deposits occur on a plateau 4000 ft. above the sea level. The rocks consist of dolomite and slates, quartz schists and laterites. Most of the ore bodies occur in the dolomites in an area of about a square mile. Lead, zinc sulphides, zinc silicates and vanadinite are the common minerals. Above the 100 ft. level they are completely oxidised and the vanadium minerals are disseminated in the soil. In the oxidized zone crystallized specimens of zinc ores, mostly phosphates are found.

Open pit method of mining is being carried on and underground stoping methods will have to be employed hereafter as the open pit mining has reached its economic unit in depth.

The laterite deposits above the 100 ft. level are the main source of the vanadium ores. As the grade is not uniform a number of faces are worked to keep the grade uniform - about 3 % V_2O_5 mostly in the form of descloizite.

The laterites are trammed to the concentrator and fed into a Hardinge mill which discharges a pulp containing 22 % solids which are passed over Wilflay tables where primary concentration takes place. Tailings are classified, the overflow going to Dorr thickeners and the underflow to Wilflay tables where secondary concentration takes place. The concentrates from both the tables are passed to a third series of tables where the grade is raised. This concentrate which contains 15 % of V_2O_5 is shipped to Europe.

Middlings

Middlings and slime concentrates containing 8.5 % V_2O_5 are used for making fused oxide. They are ground to 200 mesh in a Hardinge Mill and pumped to wooden tanks where sufficient dilute sulphuric acid is added and a solution containing 30 to 40 grams of V_2O_5 per litre is obtained. A little $Mn\ O_2$ is added to oxidise V_2O_4 to V_2O_5 during leaching. The decanted solution is filtered in a filter press and delivered to precipitation tanks where it is heated to 90°C. After four hours of heating, the precipitation of vanadic hydrate is complete. This is filtered and fused to oxide, generally containing 91 % V_2O_5.

Z I N C.

Zinc ore which consist mainly of sillicates with a little carbonate are transported to the mill and ground dry in primary crushers reducing to 6" and passed on a belt conveyor for sorting. They pass through secondary crushers where they are finally reduced to 1½". Grinding is done in ball mills to minus 200 mesh. The finely ground ore is delivered to leaching plant storage bins. Leaching is done in wood-stave tanks equipped with air lift columns. These tanks are filled with spent electrolyte and strong acid. Ground slag is added to introduce ferrous iron which is oxidised with $Mn\ O_2$.

Analysis of Ore.- Zn 25 Pb.6 V_2O_5 0.7 P_2O_5 1.5 Cl 0.12

Fe.20 insoluble 22 Cao 0.5

Slag - Zn 13, Pb. 4.5 Fe.27 insoluble 22 Cuo 8 Mgo 1.5 and V_2O_5 1.

The leach is discharged by wooden launder to acid resisting classifiers, the overflow running into lead lined sump and is pumped to silica precipitation section. The granular residue is washed by sprays to a sand pump.

The classified leach solution is pumped to wood-stave tanks with mechanical agitation and steam jets where wet ore is added to reduce the acidity. Lime is then added and allowed to stand for 3 hours. Then the solution is sent through a

Moore

Moore filtering plant. In this operation vanadium and phosphorus are precipitated by the iron and the silicic acid passes through the hydrosol, hydrogel and granular stages.

All charges are tested by colour indicators. The Moore filter units of reinforced concrete are lined in lead. Overhead cranes are used to carry the leaves from tank to tank. The leaves consist of wooden frames covered with canvas. The filtrate is carried to two heating tanks, heated to 70° c. and pumped into Nickel purification section and then to chlorine removal section and then to cadmium removal section.

The resulting zinc solution containing 100 grams per liter flows by gravity to lead lined steel tanks, mechanically agitated. Zinc dust is added to the first tank. The solution is elevated to the top of an evaporating tower, ~~the~~ two pressure fans delivering air into the base of the tower. When the temperature is dropped to 34°, it is pumped to storage tanks feeding the electrolyzing cells.

The cell room contains 444 lead lined cells. Lead lines deliver the solution to individual cells which contain 12 cascades. The cells are built of wood and lined in lead. Each cell has 42 anodes 40 cathodes and 4 cooling coils. The busbar resting on the porcelain insulators consists of rolled copper rivetted together.

Cathodes are of aluminium sheets rivetted to copper head bars. Anoden are made of local lead. The cathodes are lifted in groups of 10 after 48 hours deposition and the zinc is stripped. The stripped metal is weighed and taken to the melting room. The temperature in the cells is maintained at 40°or under. About 4,000,000 gallons of cooling water is used every 24 hours.

Cathode zinc is fed into a reverberatory furnace and poured into 56 lb. slabs. Shipments are made from the port of Beira 1328 miles from Broken Hill.

Lead production was discontinued in 1929 as production costs were high.

ASBESTOS.

Shabani.

The Shabani area extends for 5 miles and comprises two groups of mines. Two methods of winning the asbestos bearing rock are employed (1) quarrying combined with hand cobbing (2) Shrinkage stoping combined with hand pick and cobbing. Quarrying is carried on in an identically similar manner to underhand stoping - the fibre bearing rock being broken and cobbed and then shot down a winze or ore pass to the level below where it is trammed and hauled through an adit to the rock mill or up incline shafts. Blasting is done immediately before the mid-day meal.

The cobbed fibre and rock is trammed to the driers where it is placed on trays heated by means of steam pipes. From there it passes to grinding pans somewhat after the type of pug mills and then shaking screens of gradually diminishing mesh where grading and cleaning are carried out. These processes are being facilitated by suction pipes placed over the ends of the screens in order to clear the cleaned fibres. Afterwards they are sent to the central grading house where they are classified into 4 grades and bagged for shipment. At this (Asbestos in 1935 - 34,645 tons - £ 523,163) central grading mill handling is eliminated, the flow is entirely automatic from the feed to delivery of the finished product.

Birthday section was developed for stoping and a new shaft was sunk. No.2 incline shaft, 959 ft. dip 32° - 21' x 7'6". The asbestos is of the chrysolite variety and is of excellent quality. The textile fibre produced is in great demand owing to its high tensile strength and silkiness and freedom from impurities.

The

The ore bodies occur in serpentine - measuring about 10 miles by 1 mile - surrounded by a tale schist which was originally dunite. The asbestos seams are found in cracks at the contacts and in shear zones. These are short discontinuous roughly parallel dipping slightly to the south west. The fibres are normal to the plane of the seam, though occasionally they lie at an angle. The length of the fibre varies greatly, the maximum being about 3". Commercial fibre is pale green in colour, with a silky lustre and has great tensile strength. Brittle fibres are darker in colour and less silky in appearance. The ore bodies occur over a length of 3 miles. The proportion of ore is about 4 %.

Overburden is removed and hoisted up separate overburden shafts. Self dumping skips with an extensible boom resting on the dump are used for removing the overburden.

The stopes are carried on by the strnikage method leaving pillars of 30 ft. which are eventually stoped out by the same method. Crosscuts are driven through the orebody and flat back stoped with shrinkage for about 100 ft. stopes are 50 to 60 ft. wide. Fibre is cobbed in the stopes and bagged. Electric flood lighting is used in stopes to facilitate locating the fibres.

Reduction plant is erected directly on top of the shaft, feeding directly into the mill bin. Treatment is by crushing drying and air separation and grading. Primary crushing is by jaw breakers and poles with hand picking between resulting in these products, waste, going direct to the dump, hand cobs and fines. Secondary crushing in small grinding pans and then passed over wire screens over which a current of air is drawn.

The grading is done in hexagonal trommels rotating in a dust tight casing connected to an exhaust fans. Electric power is generated by suction gas engines using wood fuel.

Automatic

Automatic electric sirens are used to warn when the rain fall is great and all the boys come up to surface.

Asbestosis has not been found in the workers and strict medical examination of all workmen is being regularly done.

The workmen sign on for not more than 12 months at a time.

Shabani is 130 miles from Bulawayo, ~~and~~ 70 miles ~~and from~~ Gwelo and 60 miles from Selukwe.

CHROMITE.

Selukwe.

The deposits occur in two distinct modes (1) as irregular bodies often more or less lense shaped, ins serpentine and talc schists derived from the metamorphism of basic and ultrabasic rocks of the archaean system. The bodies are located by surface prospecting and quarried out. Actual reserves are difficult to estimate (2) as regular seams usually 4" to 10" thick in a body of basic and ultrabasic rock of dyke like habit, 33 miles long and 4 miles wide. The seams dip inwards at low angles at both margins of the dyke. In places there are two or three seams separated by 200 ft. of rock. Actual mining has proved them for 200 ft. in depth. The seams are not found along the whole length of the dyke, only in certain sections of it. Actual outcrop workings have proved that an individual seam can have a length of 6 miles on the outcrop. The tonnage of chrome one on the dyke is enormous. The abundance of high grade material which can be marketed just as it comes out of the mines makes it unnecessary to crush and concentrate. The Rhodesian chrome seldom averages less than 50 % chromic oxide and it is only the Baluchistan material that can compare with it in grade.

Production in 1935 - 102,548 tons valued at £ 128,210.

The

The Kata-Thermometer and its practical uses in Mining.

Dr. Hill and his colleagues carried out a series of exhaustive experiments, in one class of which he had seven or eight students shut in an air-tight chamber of about three cubic meters capacity which was provided with electric fans for stirring up the air ~~and~~ the temperature and the humidity of which could be varied as desired. In one experiment, they were kept there till the Co_2 content had reached 3 or 4% and the oxyge had fallen to from ~~16 to~~ 17/16 per cent, the air failing to support combustion of a lighted match, the wet bulb temperature had risen to about 83°F. and dry bulb a little higher. The discomfort was considerable, pulse rate high, faces flushed, skin and clothes moist with sweat. Stirring up the air by means of the fan gave immediate relief and lowered the pulse rate from an average of 97 per minute to 79 though no fresh air from outside was admitted Persons in the chamber breathing fresh air from outside through tubes were not relieved and persons outside breathing the vitiated "air" of the chamber experienced no discomfort. The sudden introduction of Co_2 from a bag to a percentage of 2 was not discerned by the inmates of the chamber.

A great many experiments were also carried out to determine what effect different atmospheric conditions exercise and rest had on the respiratory metabolism i.e. amount of oxygen absorbed and Co_2 expired.

The outstanding results may be summarised as follows:-

(1) Stuffiness of air is due pricipally to stagnation of heat i.e. warmth, humidity and stillness and to make air comfortable and refreshing it should have considerable cooling power, i.e. the temperature should be reasonably low, the air dry and in motion.

(2) The Co_2 even up to one per cent, has no appreciable effect on a resting person and only causes deeper breathing in a person ~~and only causes deeper breathing in a person~~ doing muscular

lar work. (Yet the ventilation standards are still held by some authorities requiring Co_2 content of rooms to be kept within 4 or 5 parts in 10,000, above outside air or say an average of .09 %).

(3) There is no evidence of organic toxins in exhaled air.

(4) The metabolism of the body is substantially increased waste products better eliminated, general health and immunity from disease promoted by living in air of low temperature, dry a and in motion.

Dr. Hill has substantiated these results from practical life and has shown from statistics that persons employed in outdoor occupations, other things being equal have greater immunity from diseases - particularly those of the respiratory organs - than those who live and work in close stuffy atmospheres.

With regard to Co_2, it is pointed out, that in aerated water factories and breweries where in some parts, the air contains 1.5 to 2.5 Co_2 per cent, the workers seem to suffer no bad effects from breathing this air for several hours each day.

In warm blooded animals, all muscular activity is accompanied by a production of heat due to oxidation or combustion of carbon in the body, the carbon being chiefly in the form of glygogen or muscle sugar. The heat production is least when the body is resting or doing internal work only such as the action of heart, lungs, digestive and eliminative organs and is considerably increased when external work is done. It is evident that if the heat is not got rid off as quickly as produced, the body temperature will rise and produce fever symptoms. The body has a marvellous heat regulating system, a mechanism which acts:

(1) By varying the blood circulation near the surface of the skin, thus varying the heat lost by radiation and convection.

(2) By varying the output of moisture through the skin and consequently

consequently the heat lost by evaporation.

This heat regulating mechanism will make desperate efforts to keep the body cool if it is physically possible but it can of course be overstrained and fatigued.

A considerable amount of heat is lost by evaporation in the respiratory tract, particularly in cool, dry atmospheres which have a low moisture content; it is greatly conducive to the health of the respiratory organs to give off a large amount of moisture as it promotes the flow of immunising fluids from the lymphatic glands to the mucous membrane.

One of the problems of the gold mining industry is to provide sufficient cooling power in the air of the workings to permit the workers to work comfortably and efficiently and without straining the heat regulating machanism by excessive sweating etc. The problem becomes more acute as the operations are carried to deeper and hotter parts of the reef.

It is possible to keep a man reasonably cool and comfortable working in an atmosphere with dry bulb 86° wet bulb 84.4° F. provided we fan him with an air current at 380 ft. per minute or just under two meters per second.

Due to convection of heat from the rock and the evaporation of moisture from water applied for drilling it will be difficult to increase considerably the cooling power in the workings from the factors of temperature and humidity and the only factor remaining is that of air movement.

D.Harrington, U.S.A. Bureau of Mines in a recent article says "In the ordinary metal mine, the velocity of air at working places is much more important than humidity, temperature and content of gases, except when the two latter go to extremes. For example men have climbed up 100 ft. out of a stope with pure still air at 79°F. and 86% relative humidity to cool off in a

level

level where the air was 3° hotter and 5% more humid than in the stope but was moving with a velocity about 150 ft. per minute". It is obvious that if the wet bulb temperature is as high as that of the body no benefit can be effected by moving the air.

Kata-thermometer.- This instrument is an alcohol thermometer having a large cylindrical bulb 4 cm. long and two c.m. diameter with a stem graduated from 95° to 100 °F. The range from 95° to 100°F. is arbitrarily chosen to given a mean temperature of 97.5°F. which is approximately that of the clothed body surface. A small reservoir is provided at the top of the stem to give a margin for overheating without bursting the bulb and to ensure that the cooling has settled down to a steady rate when the meniscus is falling from 100°to 95°.

To take a reading of dry cooling power the bulb is used bare and heated in water(about 80°c.) until the alcohol rises into the top reservoir (a thermos flask is very convenient for holding the water). The bulb and stem are then dried and then instrument suspended in the place required. The time in seconds is taken preferably by a stop watch for the meniscus to fall from 100° to 95°. To take the wet cooling power, the thin stockinguette finger stall supplies with the instrument is drawn over the bulb which is heated in hot water as before; the surplus water is then shaken off the instrument suspended and the time taken.

Each instrument is carefully calibrated and marked on the back of the stem with a factor, or co-efficient so that the factor divided by the time in seconds of cooling from 100° to 95° gives the cooling power in milli-calories ($\frac{1}{1000}$ gram calories) per square c.m. of cooling surface per second.

If H = cooling power in millicalories per sq. c.m. per sec.

K = factor of instrument

T = time in seconds for meniscus to fall from 100° to 95°

Then H = K/T.

As

As a rule several readings say 5 of each kind should be ~~tal~~ taken and the average of these taken as the cooling power. For healthy conditions Dr. Hill recommends the following dry and wet cooling powers:-

(1) Dry 5 - 7 wet 16 - 20 for sedentary occupations.

(2) Dry about 8, wet about 25 for light manual work.

(3) Dry about 10 wet 30-35 for heavy manual work.

The heat loss per sq. c.m. of the human body lightly clothed may be taken on the average as about 1/6th of the dry kata cooling power and is about 60 % of the heat loss of the naked body. For a man working stripped to the waist, a kata cooling power of 8 - 10 for a man lightly clothed. We find in practice that a dry kata cooling power of 6 and wet about 18 though not perhaps ideal is sufficient to keep a native family cool and comfortable when stripped to the waist and doing hard manual work underground without any appreciable falling off in output from that performed in cool conditions on the surface.

The use of water for dust laying purposes has two main drawbacks:

(1) the water frequently evaporates rapidly, particularly in places through which a large ventilating current is passing.

(2) it tends to saturate the air with water and this is injurious to health when sufficient air movement is not provided.

To overcome this, the use of hygroscopic substances sprayed on the walls and hanging has been tried. Belger's fluid proved itself a useful dust catcher for a period of approximately three months. The cost for one coating worked out at 9/- per 1000 sq. ft. of area sprayed. This fluid proved considerably superior to water in places with comparatively high velocities where low velocities are encountered water was found to be fairly effective, though Belger's fluid may prove to be useful on account of its low surface tension and the fact that it tends to lower the percentage of moisture contained in the air. Belger's

ger's Fluid is referred to on pages 35 and 42 of the Miners' Phthisis Prevention Committee's report.

Atomising of the fluid might prove an efficient means of dust prevention and allaying.Prof. Belger of Armstrong College, New Castle, the inventor of the fluid claims that tests have revealed that his atomiser will effectively allay drilling dust.

Belger Fluid.- This consists of a solution of 800 lbs of calcium chloride (commercial) and 50 lbs of glue in 115 gallons of water. Its original application was in laying and retaining coal dust in collieries but the inventor suggested that it might be useful in removing dust from the air in metalliferous mines.

The Belger fluid has one great advantage over water. Owing to the hygroscopic property of calcium chloride it can not dry out. Consequently dust once caught is permanently kept wet and apparently cannot be returned to the atmosphere. Further surfaces wet with Belger fluid retain their wetness for long period, the dust accumulating on it but always presenting a damp surface. Its use is limited however to air ways where the air is below the point of saturation since wet air causes the deposit to liquefy and run.

The test consisted in spraying travelling ways for the purpose of catching and retaining dust. It showed that in catching dust it had no superiority over water the reduction in in the amount of dust in the air after passing through a tunnel 500 ft. long being the same whether water or Belger fluid was used viz: half.

The solution is best made by letting the glue soak for three days in the 115 gallons of water in a sufficiently large vessel and then placing the calcium chloride in a wire basket suspended in the liquid. The glue and chloride rapidly dissolve and after solution and stirring is ready for use. It is best

sprayed

sprayed by hand with a Bordeaux nozzle set to give a medium spray so as to strike the rock furfaces with some force.

A fresh application of a weeker solution after many weeks will renew its efficacy.

GENERAL.

The total nominal capital of all the gold mines in the Transvaal is £ 81,404,283. During the year 1935, 10,491,457.67 Ozs. of fine gold was produced and disposed off as follows:-

1,524.71 Oz. to England on account of Mining Industry
7,848,645.21 Oz. to England on account of the South African Reserve Bank.
2,641,050.44 Oz. to Royal Mint at Pretoria
237.25 Oz. Sundry local sales.

The average price of gold in 1935 being 7.1 per fine oz. The total realisations amounted to £ 73,561,990.

Chief heads of expenditure in 1935 were:-

Salaries & wages £ 20,819,686
Stores " 22,755,341

The gross profit of £ 29,986,963 is not all available to share holders as a large portion is absorbed by such items as interest redemption of loans, Government taxation and share of profits etc. The total dividends declared was £ 16,777,671.

During the year 1935, 49.3 million tons of ore were crushed. The average cost per ton milled was 18 Sh. 8 d., the recovery per ton being 32 Sh. 5 d. resulting in a gross profit per ton of 13 Sh. 9 d. The average grade of the ore was 4.559 dwts.

Government Leases and Profits.- The original mining laws permitted a single individual to peg up to a maximum of 50 claims - a claim being 150' x 400' - on particular areas proclaimed as gold bearing after making the necessary allowance for the owner's and discoverer's rights. But as mining

advanced

advanced in depth, this law became unworkable owing to the peculiar formation of the reef. In 1908 a new act was passed empowering Government to reserve proclaimed mining areas from pegging and to lease the undermining rights of larger areas sufficient to constitute a workable proposition. This leasing system was further amplified by an act in 1918 by which the mining leases board was established with powers to call for tenders for proclaimed areas. In 1934 this lease system was further extended to holders of mineral rights on private lands and discoverers on crown lands, enabling them to obtain leases of workable propositions on a profit sharing basis.

Government's Share of Profits.

Government's share of profits is calculated on a sliding scale-

Y = a - b where Y is the profit payable to Government X, the ratio of profit to recovery expressed as a percentage and a and b are constants agreed to in the lease. In addition to this income, the gold mining companies have to pay excess profits duty and income-tax. The total income from all these sources to Government from the mining industry during 1935-36 was £ 14,980,000. As the gold producers complained against this excessive taxation a departmental committee was appointed to examine and report on mining taxation. After careful consideration of the existing hardships the Committee made the following recommendations in 1936 which have been adopted for the new lease mines. The scale of the present tax consists of a flat rate of 15 % and a graduated tax determined by the ratio of profit to recovery. The new formula is as follows:-

$$Y = 55 - \frac{500}{X}$$ where

Y = profit payable to Government

X = percentage ratio $\frac{\text{profit}}{\text{recovery}}$

If X is less than 12.5 the minimum basic royalty of 15 % of

of the profits must be paid and if it is over 12.5 the new formula is applied for taxation.

Oorgaum,K.G.F.,
9/4/1937.
M.S.

Chief Inspector of Mines &
Explosives in Mysore.
(in-charge).

To

The Secretary to the Hon'ble
the Resident in Mysore.

Sir,

Subject:- Deputation of Mr.K.Duraiswamier to South Africa.

Geol 71-36-2

I am directed to invite reference to this office letter No.Pol.1349/Geol. 58-35-18 dated 24th June 1936 on the above subject and to state that Mr.Duraiswamier has returned to Oorgaum, K.G.F., on 11th April 1937 after ~~successfully~~ completing his training in South Africa.

2.Government are glad to hear that Mr.Duraiswamier was shown the utmost courtesy and kindness by the officers of the Union Government and the Managers of the several mines and works which he visited, and that in particular, he is very much indebted to Dr.Pirow, Government Mining Engineer, and his staff for the facilities afforded to him for studying the several problems connected with the administration of the Mines.

3. I am to request that, if there is no objection, ~~the Government of India may be kindly addressed to convey to the Union Government~~ may be conveyed to the Govt of the Union of South Africa the cordial thanks of His Highness' Government for the facilities afforded to Mr.Duraiswamier and the courtesy extended

to him during his stay at S. Africa.

I have etc.,

30/4/37

Secretary to Government,
Development Department.

Memo No. D7496

Copy to the Chief Inspector of Mines & Boilers for information with ref to his letter No 2388 dated 9/4/37

B.O

30/4

Secretary to Govt
for Director of Agri-

GOVERNMENT OF HIS HIGHNESS THE MAHARAJA OF MYSORE

General and Revenue Secretariat

Dated, Bangalore, 6th May 1937.

No. PoC 1397/Genl 71-36-2

From

The *Secretary to the Government of His Highness the Maharaja of Mysore, Development Department.*

To

The Secretary to the Hon'ble the Resident in Mysore.

Sir, SUBJECT:- Deputation of Mr.K.Duraiswamier to South Africa.

I am directed to invite reference to this office letter No. Pol.1349/Geol.58-35-18 dated 24th June 1936 on the above subject and to state that Mr.Duraiswamier has returned to Oorgaum, Kolar Gold Field on 11th April 1937, after completing his training in South Africa.

2. Government are glad to hear that Mr.Duraiswamier was shown the utmost courtesy and kindness by the officers of the Union Government and the Managers of the several mines and works which he visited and that in particular, he is very much indebted to Dr.Pirow, Government Mining Engineer, and his staff for the facilities afforded to him for studying the several problems connected with the administration of the Mines.

3. I am to request that, if there is no objection, the cordial thanks of His Highness' Government may be conveyed to the Government of the Union of South Africa for the facilities afforded to Mr. Duraiswamier and the courtesy extended to him during his stay at South Africa.

I have the honor to be,
Sir,
Your most obedient servant,

Sd/- V. Vedavyasacharya,
Secretary to Government,
Development Department.

Memo No. D 7496.

Copy of the above is forwarded to the Chief Inspector of Mines and Explosives for information with reference to his letter

P.T.O. No.

No.2388 dated 9th April 1937.

By Order,

For Secretary to Government,
Development Department.